International Journal of Informatics Society

04/12 Vol. 4 No. 1 ISSN 1883-4566

Informatics Society

Aims and Scope

The purpose of this journal is to provide an open forum to publish high quality research papers in the areas of informatics and related fields to promote the exchange of research ideas, experiences and results.

Informatics is the systematic study of Information and the application of research methods to study Information systems and services. It deals primarily with human aspects of information, such as its quality and value as a resource. Informatics also referred to as Information science, studies the structure, algorithms, behavior, and interactions of natural and artificial systems that store, process, access and communicate information. It also develops its own conceptual and theoretical foundations and utilizes foundations developed in other fields. The advent of computers, its ubiquity and ease to use has led to the study of informatics that has computational, cognitive and social aspects, including study of the social impact of information technologies.

The characteristic of informatics' context is amalgamation of technologies. For creating an informatics product, it is necessary to integrate many technologies, such as mathematics, linguistics, engineering and other emerging new fields.

Guest Editor's Message

Satoru Fujii
Guest Editor of the Tenth Issue of International Journal of Informatics Society

We are delighted to have the seventh and special of the International Journal of Informatics Society (IJIS) published. This issue includes selected papers from the Fifth International Workshop on Informatics (IWIN2011), which was held in Venezia, Italy, Sep 16 - 21, 2011. The workshop was held at Royal British Hotel. This workshop was the fifth event for the Informatics Society, and was intended to bring together researchers and practitioners to share and exchange their experiences, discuss challenges and present original ideas in all aspects of informatics and computer networks. In the workshop, 27 papers were presented at seven technical sessions. The workshop was complete in success. It highlighted the latest research results in the area of networking, business systems, education systems, design methodology, groupware and social systems.

Each IWIN2011 paper was reviewed in terms of technical content and scientific rigor, novelty, originality and quality of presentation by at least two reviewers. From those reviews, 14 papers are selected for publication candidates of IJIS Journal. This tenth includes four papers of them. The selected papers have been reviewed from their original IWIN papers and accepted as publication of IJIS. The papers were improved based on reviewers' comments.

We hope that the issue would be of interest to many researchers as well as engineers and practitioners in this area.

We publish the journal in print as well as in an electronic form over the Internet. This way, the paper will be available on a global basis.

Satoru Fujii is a professor emeritus at Matsue College of Technology, Japan. He received the Professional Engineer (Information Engineering) in 1990, and received Ph.D. from Shizuoka University in 2005. He worked as a computer scientist at Matsushita Electric Co. Ltd. (Panasonic) from 1968 to 1994. He is a visiting lecturer at Shimane University since 2011. His research interests include e-Learning, mobile communication system and virtual reality. He is a member of the Institute of Electronics Information and Communication Engineering (IEICE) and Japan Society for Information and Systems in Education (JSiSE).

IPv6 Status and Uses

Peter T. Kirstein*

*Department of Computer Science. University College London, UK

Abstract –The paper provides an introduction to a talk on nature, scope, urgency of need of introduction and some important applications of the next generation IPv6 protocol. While the general characteristics are well-known, the talk gave data on the urgency of the need for deployment. Some of the newer protocols that depend on IPv6 are disussed. Some newer applications, particularly Smart Grids and Personal Communications are discussed specifically. An urgent need for training has been identified in a companion project (6DEPLOY). Some of its accomplishments are mentioned.

Keywords: ARPANET. IPv6, new protocols, smart metering, protocol transition, training.

1 INTRODUCTION

When I was asked to give a keynote to IWIN2011, I neither knew the interests of the audience nor the depth at which a subject should be addressed. It was clear that it should be about the current network activity, but even here there was a wide choice. I decided that the status and prospects of IPv6, as the next generation of Internet activities, seemed appropriate. While in the actual talk, it was the status of IPv6 and various activities around it that was presented. I was asked in this introduction to present some background on my previous work on the Internet. After some thought, I decided that this was indeed very appropriate. First I was of the generation that had lived through a previous transition of network technologies. Second, I had been very occupied in dealing with legacy infrastructure while moving as rapidly as possible into the next generation; this again would apply with the opportunities that were going to be offered by IPv6. Finally, while the present audience might be well aware of of the status and extent of Japanese activities in this area, the world scene would be much less familiar to them. By putting in some of the historical activity, the world perspective would become much more comprehensible.

In Section 2, I give a brief account of our activities in the context of ARPANErpanet, and then in Section 3, those in the context of the Internet with IPv4. In Section 4, we progress then to the current status of IPv6 and some future directions. The present situation is much more complex than that in 1981, when we were changing to the Internet, and the extent of the user community much larger – including many less network-aware. Hence we discuss some training with which we are involved.

2 FROM ARPANET TO INTERNET

The UK activities here have been well-documents in [1], [2]. In 1973, the Kjeller national computer Centre in Norway and the UCL Institute of Computer Science each got a Terminal Interface Message Processor (TIP) which could be connected to the Arpanet. The TIP could support some 32 terminals, either local or coming in by telephone lines. It could also support three additional computers. Because of the way the communications were configured at the time, there was a satellite connection at 9.6 Kbps to Kjeller and then a 9.6 Kbps undersea cable link to UCL. The main purpose of the Norway site had been to connect in a seismic array. While a substantial computer at the computer centre was connected to that TIP, the only way of using it was by going physically to the Computer Centre; the owners had no interest in providing access to remote users, and did not connect the TIP terminal ports to the telephone network. By contrast, the UCL TIP was immediately connected up to the telephone network with some 8 lines and to a large IBM-360/195, the largest machine at that time in the academic community in the UK. That machine was located in the Rutherford and Appleton Laboratory (RAL), some 100 Kms from UCL, and connected by a reasonably slow leased line.

On the one hand, we used the TIP capability to the full to allow users to dial in to the TIP over the telephone network. The only action of the UCL computer was to force users dialing into the TIP to provide a username/password (this facility had not yet been implemented on the TIP. On the other hand, the RAL machine was already the hub of a centralized computer network with links to many UK universities. These links ran remote job entry services, but also had a limited capability to communicate with users on another such link; this was a so-called HASP terminal normally running on a small IBM-1130 computer. My group programmed its PDP-9 mini-computer so that it simulated a HASP terminal, and thus could communicate to users on other such terminals, could transmit files and could run jobs. The PDP-9 was attached to the TIP as if it was a standard ARPANET terminal running all the ARPANET protocols. Since this configuration provided exactly the termination required by both ARPANET and HASP, it was easy to arrange that users of the HASP system could access computers on the ARPANET, and that users of Hosts on the ARPANET could use the RAL machine [3]. Moreover, since some machines on the ARPANET already ran electronic mail, these facilities provided UK academic users access to electronic mail. Over the next 15 years, these services were progressively enhanced – requiring only that our facilities kept pace with the developments in each country separately; it was not necessary for the evolving systems in the two countries to synchronise their implementations with each other. Thus the US side could evolve from the early ARPANET NCP to the much more sophisticated IPv4 Internet with all its advanced features including the Domain Name System. The UK could evolve from its early centralized HASP system, through its more distributed SRCNet, and then its complete family of so-called Coloured book protocols with its Name Registration Scheme , before it finally converged also onto the IPv4 Internet. The evolution of the UK system is well described in [1] [7]. Throughout this period, my UCL group ensured that complete interoperability was maintained.

Throughout this period we also undertook network advances – though trying to ensure relative compatibility across the Atlantic where feasible. Thus we were an important member of the DARPA SATNET experiment [4]; indeed we were the only partner to use it in a service capacity in the early '80s for our UK-US service. We did one of the first three implementations of TCP/IP, and were the first to go over to using the IPv4 protocols in an Internet service capacity – a year before the ARPANET went over to those protocols in January 1983. On the UK side, we provided access over the emerging UK packet services, again using them in a service role to run IP over them to the ARPANET. We did the first facsimile transmission over ARPANET [5]. We provided the first conversions between the internationally standardized X.400 mail systems and the Internet SMTP mail.

The transition from the original NCP to IP was traumatic for US Host sites; each Host had to change its communications protocols. The transition for the UK sites was not noticed by them – only by us. We ran the old protocol conversions on our old PDP9s, while we developed our new systems on new PDP-11s. Since the Internet protocols became very stable on these newer machines, thanks to excellent engineering by the Berkeley UNIX group, it was mainly necessary to port our coloured book code and modify the conversions. This we were able to do at leisure. However, when I say traumatic above, it was very limited in scope. There were only just over 200 Hosts on the ARPANET on transition, and almost all of these were in an R & D environment. Very few were even in important commercial situations.

The way we connected networks was different initially from the standard DARPA approach. This led to the first paper categorizing the way networks could be connected [6], and later a discussion of how we provided the relay services [7].

Of course the group did many other activities on computer networks and their applications during the subsequent decades, but these are not germane to the main subject of the talk.

3 FROM IPV4 TO IPV6

In 1974, only 5 years after the ARPANET went live, we realized that a new protocol suite was needed. It was then that we started working on Cerf and Bob Kahn's Internet Protocol. By 1992, around a decade after IPv4 went live, we realized its lifetime was also limited. This was the time when the World Wide Web was coming into prominence, and it was clear we would eventually run out of address space for new entities. As a result, one started working on the next generation Internet protocols. The result was IPv6, whose basic standards were ratified by 2001. This not only increased substantially the address space, but also cleaned up in a number of problem areas. It also specified a number of features as obligatory, which had been omitted from the original IPv4 standards, though they had been defined later. Examples of these are security and mobility support.

It is beyond the scope of both this introduction and the talk itself to give any description of the huge volume of work and publicatoins of work on IPv6. Just as we started working on IPv6 implementations long before the basic standards were ratified. We were using it in an EU project on network management as early as 1998 [8]. Once the basic specifications had been ratified in 1998, a number of actions happened in parallel. These included the following:

- Considering how the multitude of existing further standards would fit above IPv6.
- Ensure that the different applications interests would be catered for by the new standard
- Worked on standards for new functionality, only on the basis of IPv6 – e.g. network mobility and low power networks
- Started defining a transition strategy for moving from IPv4 to IPv6
- Developing a series of implementations.

The Japanese were particularly active in this phase of the development with Open Source implementations and testing in the context of the Kame, USAGI and Tahi projects [9], [10]. From 2001, there were also a series of application trials under the auspices of the WIDE project [11].

Some of the characteristics of IPv6, the status of its implementations and the rate at which address space was running out are discussed in the slides. This also gives a snapshot of the status in September 2011.

The huge address space of IPv6 was needed by, and facilitates, many new applications. Some examples of these in emergency communications and smart power are discussed also in the talk.

The transitioning of organizations to the new standard has been very slow – as is again discussed in the talk. One reason for this has been identified as the need for training and the need to transition applications which were not written with this transition in mind. Again some projects to provide training are described in the talk [12].

Although the transition to IPv6 has been very slow, it is now gathering pace – in view of the increasing difficulty of getting IPv4 address space. There are now many experts – both as consultants and as educators – to aid with the trasition to IPv6. There are many national bodies set up under the auspices of the IPv6 Forum [13] to help with the conversion. There is even an "IPv6 Ready" award that one can obtain to verify that any particular implementation is aligned to the standards [14].

We are incomparably better prepared to move over to IPv6 – both in scale and sophistication. However, in view of the numbers involved, the current transition will be much more more challenging than that in 1982.

A strong contributor to the difficulty of the current transition plan, is the large numbers of members of other communities that will be involved this time. As we move into areas like Electric power generation and distribution, automobile design, building automation and emergency communication, Their communities are only now moving slowly towards incorporating IPv4. Since they are making their large investments now, it will be very difficult for them to undertake the new task of getting to understand why IPv6 is the way they ought to move. I fear that in many of these categories, most will equip themselves first with IPv4, and there may be a long interval before they understand that IPv6 would allow them to make full advantage of the IPv6 features. That have been heard.

(Received November 27, 2011)

REFERENCES

[1] P. T. Kirstein, "Early Experiences with the ARPANET and INTERNET in the UK", IEEE Annals of Computing, Vol.21, No.1, pp.38-44 (1999).
[2] P. T. Kirstein, "The early History of Packet Switching in the UK", IEEE Communications Magazine, Vol.47, No.2, pp.18-26 (2009).
[3] P. L. Higginson, P. T. Kirstein, and A. V. Stokes, "The Problems of Connecting Hosts into ARPANET via Frondend Computers", Workshop on Distributed Computer Systems, Darmstadt (1974).
[4] P. T. Kirstein, C. Bradbury, R. C. Cringle, H. R. Gamble, R. Minder, D. McNeill, J. Cole, R. Bressler, and D. L. Mills, "SATNET Applications Activities", Proc. Nat. Telecom. Conf., Washington, 45.1.1-45.1.7 (1979).
[5] P. T. Kirstein, and S. Yilmaz, "Facsimile Transmission in Message Processing System with Data Management", Proc. 4th ICCC, pp.717-726 (1978).
[6] V. G. Cerf, and P. T. Kirstein, "Issues in Packet Network Interconnection", Proc. IEEE, Vol.66, No.11, pp.1386-1408 (1978).
[7] P. T. Kirstein, "The Network Relay and Protocol Translation Services Provided by University College London", Proc. Conf. Comm. Distrib. Systems, pp.316-338, Springer Verlag, Berlin (1984).
[8] Q. Cabell, P. T. Kirstein, T. Pagtzis, T. Tiropanis, and L. Wang, "The Use of TINA Principles in the Management of Internet Multimedia Conferences", Proc. IS&N99, Barcelona, pp.482-498 (1999).
[9] http://www.kame.net/project-overview.html
[10] http://www.cu.ipv6tf.org/pdf/v6esaki.pdf
[11] Internet2 Speakers Bureau: People: Hiroshi Esaki
[12] 6DEPLOY - IPv6 Deployment and Support - Tutorials
[13] IPv6 Forum: Driving IPv6 Deployment
[14] http://www.ipv6ready.org/IPv6
[15] Real Help for your Network's IPv6 Transition | ZDNet

Peter T. Kirstein was born in Germany in 1933. He grew up in England and obtained his BA in Mathematics and Electrical Engineering from Cambridge University in 1954, a Ph.D in Electrical Engineering from Stanford University in 1957 and a D.Sc. from London University in 1970. After a period at Stanford University, CERN in Geneva, and US General Electric Research and Development Center based in Zurich, he joined the University of London Institute of Computer Science in 1967, first as Reader and becoming in 1970 Professor of Computer Communications Systems. In 1973 he joined the Department of Statistics and Computer Science of University College London, In 1980 he was appointed as the first Head of its Department of Computer Science, a post he held from 1980 until 1994. For the following decade he was Director of Research. Currently he participates in several research projects concerned with aspects of computer networks - e.g. satellites, security, IPv6 and the "Internet of Things". He is a Fellow of many professional bodies including the Royal Academy of Engineering, British Computer Society, Institute of Physics, Institution of Electrical Technology, Senior Member Institution of Electrical and Electronic Engineers. He is a Foreign Fellow of the US National Academy of Engineering and the American Academy of Arts and Science. His awards for his work on computer networks include Commander of the British Empire, Lifetime Achievement award of the Royal Academy of Engineering, Postel Award, ACM Communications Society and Senior Medal of the Institute of Electrical Engineers.

IPv6 status and Uses

Peter T. Kirstein
University College London

The Theme of the Talk

- There are many current considerations of the shape of the future Internet
  - The only immediate candidate is IPv6
- Information on what it is, why it will come, and what it will bring are vital to all
  - But the planning for the transition is slow
- Many regions are ready to move in this direction
  - I will indicate what is happening here
- The transition will require training
  - Some of the training initiatives will be mentioned here
- What are the advantages, and why must it happen?

Contents of Talk

- The Internet and IPv4 and address depletion
- What is IPv6, and its advantages
- How near is transition to IPv6?
- New Protocols and IPv6 drivers
- Some important applications that would benefit
- Training and 6DEPLOY

19 June 2011 IWIN Workshop 3

Contents of Talk

- *The Internet and IPv4 and address depletion*
- What is IPv6, and its advantages
- How near is transition to IPv6?
- New Protocols and IPv6 drivers
- Some important applications that would benefit
- Training and 6DEPLOY

19 June 2011 IWIN Workshop 4

IPv4, IPv6 and Address Depletion

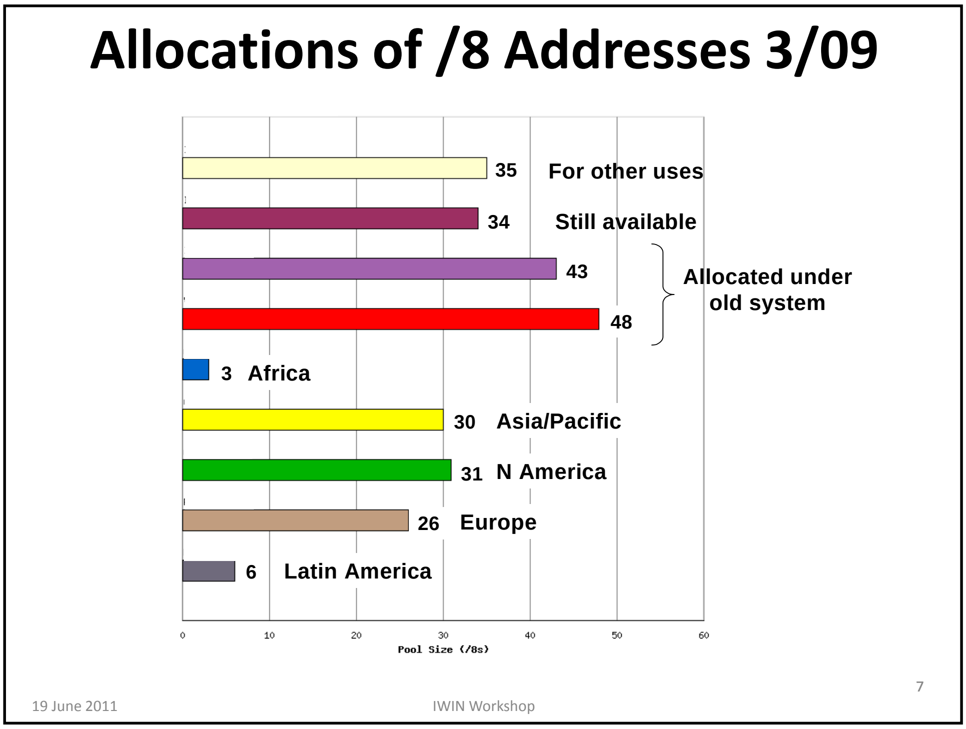
- Because of its 32 bit address length, IPv4 has 256 blocks of 16 M addresses – called a /8
- There is a mechanism for allocating the addresses
  - But they are being used up at a rapid rate
- There are many aspects of IPv4 protocols that one thinks now need improvement
  - But address depletion is an important driver
- We decided around 1990 that a re-think of current IPv4 protocols was needed
  - Result was IPv6
  - Much larger address space and other improvements

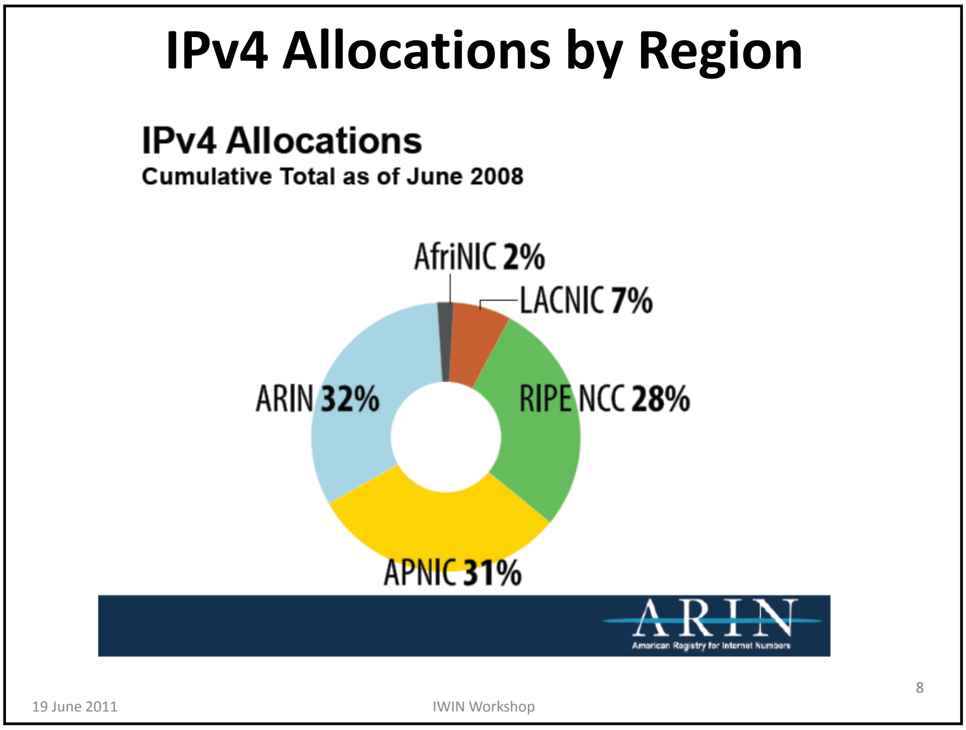
19 June 2011 IWIN Workshop 5

Mechanism of IPv4 Address Allocation

- IPv4 addresses used to be allocated in an *ad hoc* fashion
  - I personally held two /8 blocks for .UK and .Int!
- Now there is a system of Internet Registries
  - World (IANA), Regional (RIRs), and Local (LIRs)
  - RIRs allocate blocks to Local Internet Registries (LIRs)
  - LIRs allocate blocks to end users
- IANA allocates /8 blocks to RIRs – No charge
  - RIRs have their own policies on such allocations
  - LIRs have their own policies subject to some RIR rules
  - All provisions are only on a cost recovery basis
- See http://www.nro.net/documents/comp-pol.html

19 June 2011 IWIN Workshop 6


Allocations of /8 Addresses 3/09
35 For other uses
34 Still available
43
48
Allocated under old system
3 Africa
30 Asia/Pacific
31 N America
26 Europe
6 Latin America
0 10 20 30 40 50 60
Pool Size (/8s)
7
19 June 2011
IWIN Workshop

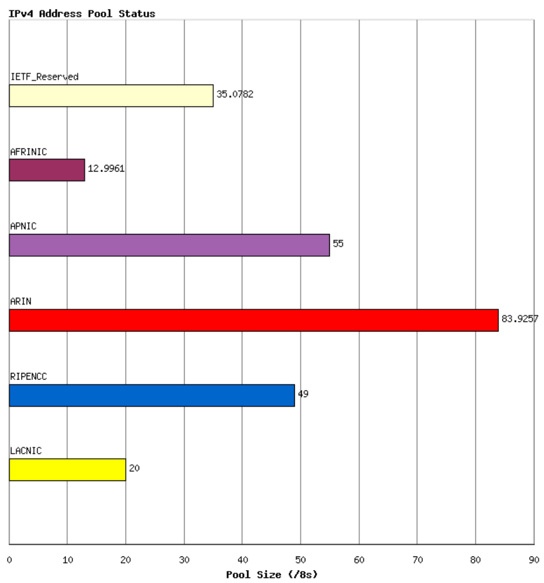

IPv4 Allocations by Region
IPv4 Allocations
Cumulative Total as of June 2008
AfriNIC 2%
LACNIC 7%
ARIN 32%
RIPE NCC 28%
APNIC 31%
ARIN
American Registry for Internet Numbers
8
19 June 2011
IWIN Workshop

Estimate of RIR Exhaustion Date

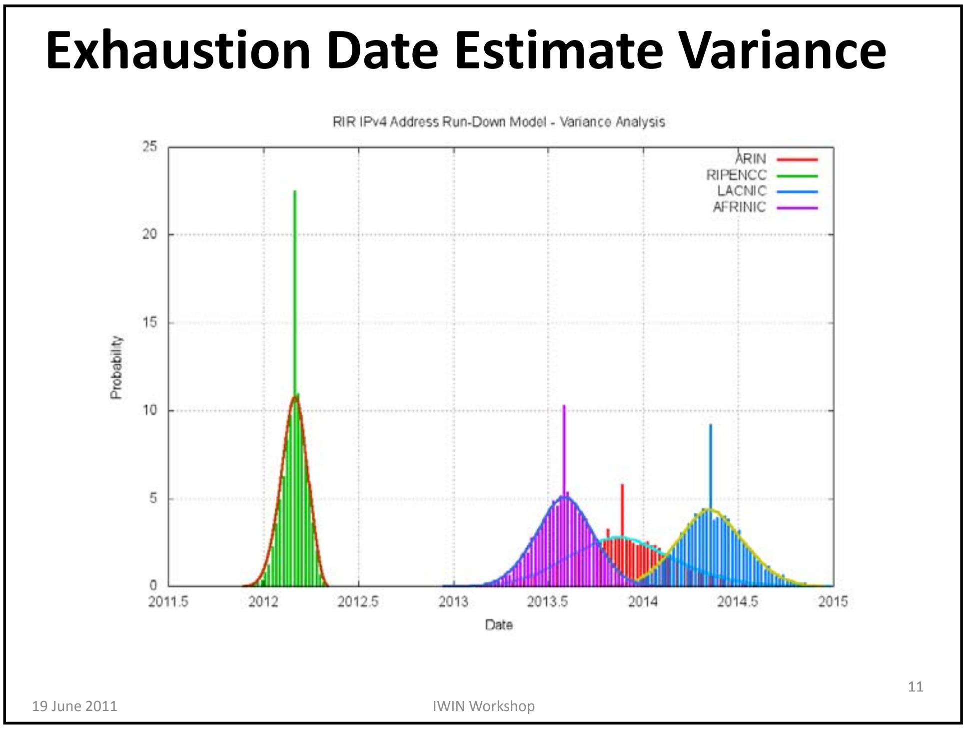
- Exhaustion defined as when last /8 is reached
- When exhaustion date reached much firmer allocation policies are introduced
- Estimated Exhaustion Dates (at current rates)
  - APNIC:19-Apr-2011
  - RIPENCC:28-Feb-2012
  - AFRINIC:31-Jul-2013
  - ARIN:20-Nov-2013
  - LACNIC:08-May-2014
- Exhaustion date does not mean end, but much stricter rules on allocation – e.g. at most 1 K address

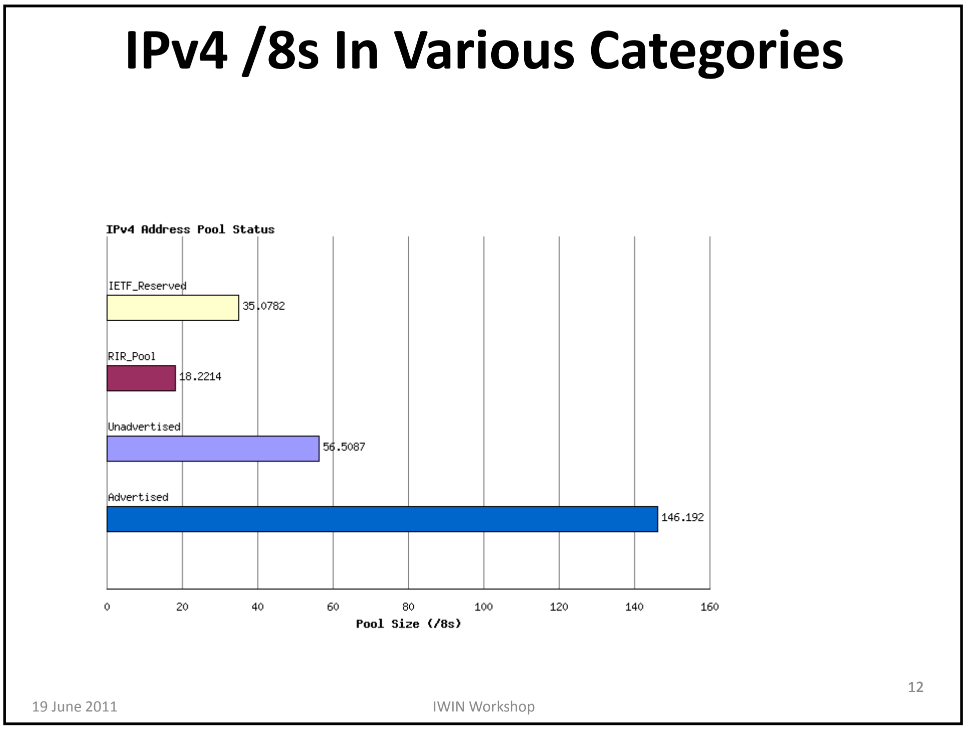
19 June 2011 IWIN Workshop 9

IPv4 Allocations by Region – 2/11



19 June 2011 IWIN Workshop 10


Exhaustion Date Estimate Variance
RIR IPv4 Address Run-Down Model - Variance Analysis
ARIN
RIPENCC
LACNIC
AFRINIC
Probability
Date
19 June 2011
IWIN Workshop
11


IPv4 /8s In Various Categories
IPv4 Address Pool Status
IETF_Reserved
35.0782
RIR_Pool
18.2214
Unadvertised
56.5087
Advertised
146.192
Pool Size (/8s)
19 June 2011
IWIN Workshop
12

Urgency due to Address Depletion

- Address depletion stated too often
  - but now there
  - http://www.potaroo.net/tools/ipv4/
- Address Exhaustion when lLast /8 reached
- Triggers new emergency mechanisms to conserve space
- IANA reached last 5 /8s in February 11
  - Allocated last 5 /6 blocks to RIRs
  - APNIC reached last /8 in April 2011
- Will only get much smaller number of global IPv4
- Has impact on new applications which need global
  - applications (particularly with security) or p-p

Activities in Regions

- Mature regions have much larger historic allocations
  - Hence have less urgency to move to IPv6
- Asia-Pacific and Africa have much worse problem
  - Many have major interest in large-scale growth
  - Particularly China, Japan, Korea had to move fast
- All three have large deployments
  - CERNET-2 all IPv6 with 10 Gbps
  - China says they will go all IPv6 by 2016
  - Japan has had WIDE development project since 1999

Contents of Talk

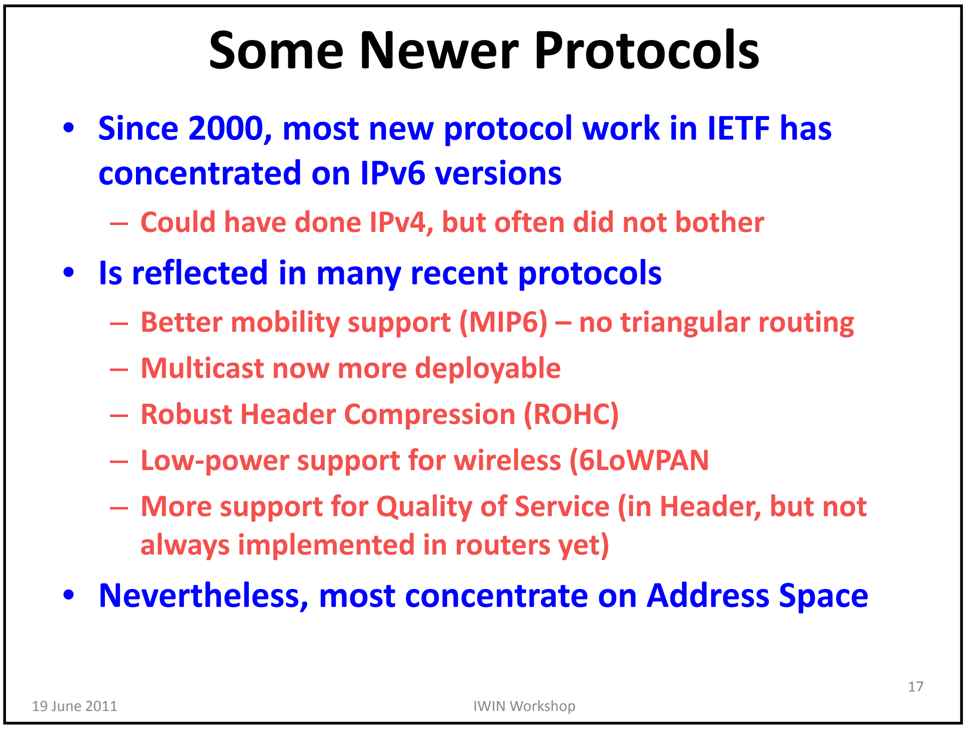
- The Internet and IPv4 and address depletion
- ***What is IPv6, and its advantages***
- How near is transition to IPv6?
- New Protocols and IPv6 drivers
- Some important applications that would benefit
- Training and 6DEPLOY

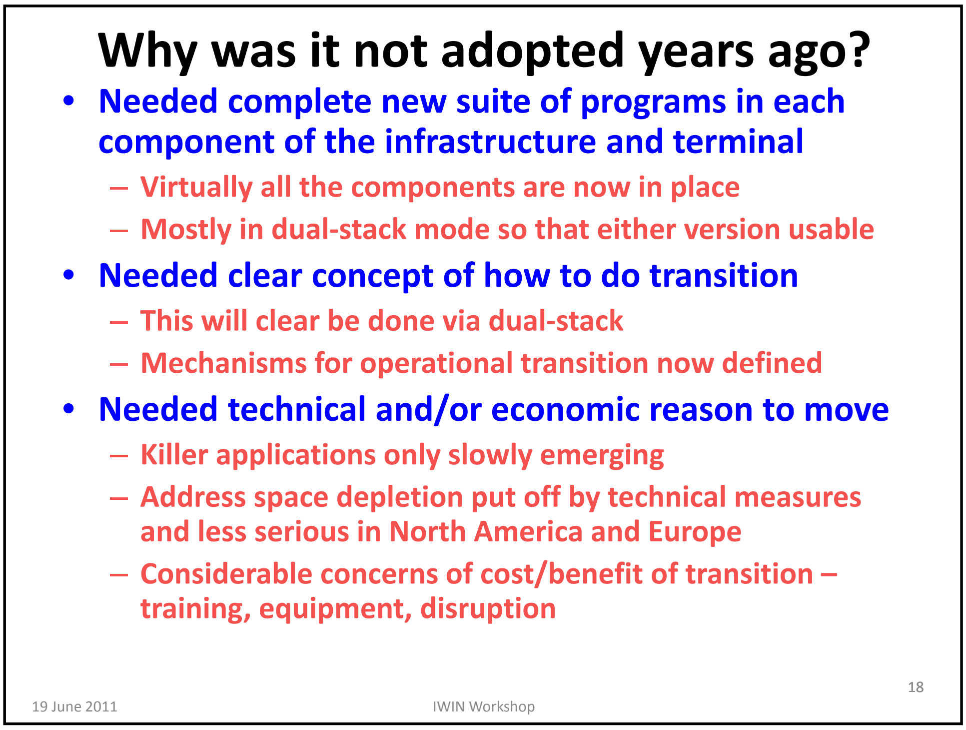
19 June 2011 IWIN Workshop 15

What is IPv6

- Successor to current IPv4 Internet Protocol
  - Under development since about 1993
  - Ratified as Standard by IETF around 2001
- Principal characteristics
  - Much more address space – 128 bits instead of 32
  - Mobile IP support mandatory (better than in IPv4)
  - IPSEC mandatory (could be done in IPv4)
  - Better auto-configuration
  - Better multicast
  - More space for flow-control options
  - More efficient processing of header options

19 June 2011 IWIN Workshop 16


Some Newer Protocols
• Since 2000, most new protocol work in IETF has concentrated on IPv6 versions
– Could have done IPv4, but often did not bother
• Is reflected in many recent protocols
– Better mobility support (MIP6) – no triangular routing
– Multicast now more deployable
– Robust Header Compression (ROHC)
– Low-power support for wireless (6LoWPAN
– More support for Quality of Service (in Header, but not always implemented in routers yet)
• Nevertheless, most concentrate on Address Space
19 June 2011
IWIN Workshop
17


Why was it not adopted years ago?
• Needed complete new suite of programs in each component of the infrastructure and terminal
– Virtually all the components are now in place
– Mostly in dual-stack mode so that either version usable
• Needed clear concept of how to do transition
– This will clear be done via dual-stack
– Mechanisms for operational transition now defined
• Needed technical and/or economic reason to move
– Killer applications only slowly emerging
– Address space depletion put off by technical measures and less serious in North America and Europe
– Considerable concerns of cost/benefit of transition – training, equipment, disruption
19 June 2011
IWIN Workshop
18

Contents of Talk

- The Internet and IPv4 and address depletion
- What is IPv6, and its advantages
- *How near is transition to IPv6?*
- New Protocols and IPv6 drivers
- Some important applications that would benefit
- Training and 6DEPLOY

19 June 2011 IWIN Workshop 19

Current Status

- Impact of address depletion imminent
- Major studies done on cost of transition
  - E.g. GSA, DoD in US
- Research activities 2000-2006 showed ease of putting dual-stack in the network core and terminals
  - DoD pilots and testbeds 2005-2007
- Most Research networks now dual-stack
- Terminal equipment often has IPv6 1st choice
  - Microsoft since Vista, IPv6 preferred, goes to IPv4 if needed
  - Mobile have IPv6 since v 4.1 of WIN-CE6, Symbian OS7.0 Linux and BSD have long had IPv6 standard
  - Most big providers move to dual stack
    - Though not all applications as complete (e.g. Cisco VoIP/CUCM)
- June 8 IPv6 day

19 June 2011 IWIN Workshop 20

IPv6 Day

- Big providers showed IPv6 readiness
  - Google, Yahoo, Akimai, Cisco
- Large User Organisations showed they were ready
  - E.g. NRENs, SPAWAR, some enterprise sites
- Traffic proportion IPv6 still low – typically 0.1%
  - But went up 60% on day dropping to 30% thereafter#
- However there were few real problems
  - Most solved on the day
- Expect steady migration of major services permanent
  - Also expect IPv6 week in February 12

19 June 2011 IWIN Workshop 21

The Pioneers Advance Slowest

- Europe and North America started Internet earliest
  - Have by far largest allocations, hence less need to move fast
  - Have large deployment, so reluctant to move fast
  - Have most advanced components, so loathe to move fast
- China, Japan, Korea have greatest need and incentive
  - Do not have same reserves of IPv4 address space
  - Have more capital to invest currently
  - Would like to leap-frog Europe and North America
- US main computer components well developed for IPv6
- Europe and N. America slow to move processes and applications to IPv6

19 June 2011 IWIN Workshop 22

Stages of Adoption of IPv6

- There have been many studies of the stages needed to transition to IPv6
  - A good one will be published shortly by the ECC committee of CEPT
- The report outline the stages for public IPv6 transition:
  - 1 The core backbones must go dual-stack
  - 2 The ISP must embrace dual-stack working
  - 3 Content servers must become IPv6 accessible
  - 4 User equipment may become dual stack
- The report also analyses the progress of the different countries along this path
  - In general, it is a long haul to get organisations transitioned

19 June 2011 IWIN Workshop 23

US DoD Transition Good Case Study

- 2001 Electronics Board tasked to produce strategy
- 2003 Came up with broad policy
  - All new systems from 03 be IPv6 capable, IPv4 Interoperable
  - Support testbed (NAVIPv6) in university
  - Identify a at least 3 major projects that could be IPv6 Pilots
  - Transition 2005 – 2007
  - DISA manage and control all IPv6 address space for DoD
- Set up labs and testbeds
  - With ever increasing functionality
- Set major standards for DoD
- Built database of accredited suppliers and applications
  - Working closely with industry

19 June 2011 IWIN Workshop 24

Japan More General Strategy

- WIDE Project worked on IPv6 from 2000
  - Strong involvement from industry
  - Director, Murai, moved to Prime Minister's Office
  - Built IPv6 infrastructure around 2000
  - KAME to provide IPv6 OS around 2000
  - Worked on mobile applications (and cars)
  - Equipped major building in Keio U for energy monitoring and conservation
- Sony early research activity including 6NET
  - 2004 stated all relevant future projects would be IPv6
  - Withdrew from effort on in games in 6NET to continue it in Japan
  - Games are p – p and need the IPv6 addresses

19 June 2011 IWIN Workshop 25

European Framework Research

- Significant pilot network projects 2000 – 2005
  - 2000-2003 6INIT (infrastructure), 6WINIT (mobile apps)
  - 2003-2005 Serious Pilots 6NET (network plus apps), EuroIX (Internet exchanges), Security
- Training and Applications 2006 – 2009
  - 2006-2010 6LINK, 6DISS, 6DEPLOY, 6CHOICE
  - 2007-2009 Civil Protection (U2010), 6Power, 6SAT
- From 2010 no particular IPv6 Projects
  - But assume that most projects will use IPv6 in their execution
- Research Infrastructure GEANT dual stack
  - Most European NRENs also dual stack
  - Very few universities have much IPv6

19 June 2011 IWIN Workshop 26

Many Actively Promoting IPv6

- **IPv6 Forum frequent Awareness Meetings**
  - Many national IPv6 Task Forces
  - IPv6 Readiness Logos
- **2008: European Commission IPv6 Action plan**
  - Propose 25% users be able to connect with IPv6 by 2010
  - Proposes EC and EU e-Gov sites be enabled
- **2009: 1st EU Agency provides IPv6 web access**
  - European Network &Information Security Agency (ENISA)
- **IPv6 EU Deployment Monitoring Survey**
  - By TNO, GNKS Consult and RIPE
  - 610 respondents, including government bodies, ISPs, other technology houses, and education

19 June 2011 IWIN Workshop 27

Survey results: European IPv6 use

- **79% have or in process of getting IPv6 addresses**
  - 97% of educational institutes have IPv6 addresses
- **17% using IPv6**
  - 8% of ISPs are using IPv6
- **30% concerned about IPv4 depletion**
  - Compared with 48% concerned outside the EU
- **Why not deployed yet?**
  - 70% No business case
  - 57% lack of user demand

19 June 2011 IWIN Workshop 28

Contents of Talk

- The Internet and IPv4 and address depletion
- What is IPv6, and its advantages
- How near is transition to IPv6?
- *New Protocols and IPv6 drivers*
- Some important applications that would benefit
- Training and 6DEPLOY

19 June 2011 IWIN Workshop 29

New Protocols

- Survey indicates lack of interest or understanding of urgency
- Neither organisations nor user understand the impact of protocol progress over last eight years
- IETF has concentrated on IPv6 with new protocols
  - Many could be developed for IPv4, but have not been
  - Examples are improved 6LowPAN (low power protocols), ROHC (Robust Header Compression), MIP6 (mobile users), NEMO (mobile networks), MANEMO (Mobile ad hoc)
- Thus many of the future applications do not really have good IPv4 protocol support

19 June 2011 IWIN Workshop 30

Future Driving Needs for IPv6

- Know predicting future is a mug's game
- Mobile Important driver
  - IMS needs global access, agreed that it be IPv6
  - As VoIP goes mobile, needs many addresses, not IPv4
- Smart grids being developed globally
  - Needs many addresses
- All peer-peer traffic
  - Games, VoIP, Conferencing, Supplier push advertising
- Major interactive automobile services
  - Again problems of data push if private addresses

19 June 2011 IWIN Workshop 31

Contents of Talk

- The Internet and IPv4 and address depletion
- What is IPv6, and its advantages
- How near is transition to IPv6?
- New Protocols and IPv6 drivers
- ***Some important applications that would benefit***
- Training and 6DEPLOY

19 June 2011 IWIN Workshop 32

The Internet of Things

- There is a general agreement that the *Internet of Things (IOT)* will be the biggest future Internet User
  - Though nobody really knows how and what it is
- The EC has a major IOT programme
  - Which has world-wide international links
- At least the EC programme believes that while many end-devices will not be IP, wide-area communication must be Internet
  - They even believe it will have to be IPv6
- Several projects are investigating the role of IPv6
  - Including IOT6 which includes UCL

19 June 2011 IWIN Workshop 33

IOT6

- IOT6 is investigating how IPv6 addressing can be used to reach non-IP entities
  - Here the large address space and the local use of multicast may allow robust use of gateways
- Wide Area it will capitalise on the strengths of IPv6
- Its gateways will be mulit-level, and may be distributed – using IPv6 features
- We will investigate which information should be carried at the packet level
  - And which must be at the application level
- There will be a major practical demonstration in automating new buildings

19 June 2011 IWIN Workshop 34

Smart [power] Grid

- Smart Grids are being developed globally
  - Make grid more efficient – potential large cost savings
    - US estimated $56- $112 Billion saving in 20 years
    - 2005: Italy - Telegestore project €2.1B – annual savings €500M per year!
- 2009: US Smart Grid Initiative - $8.1 Billion
  - 40 Million smart meters
  - http://www.nist.gov/smartgrid
  - Smartgrid BoF at IETF76 in Japan, Nov 2009
  - Happening fast – standards to be ready by end 2010
- Large number of addresses => Need for IPv6
  - Could be done with IPv4 and private address spaces but would be much harder and constrain customers

19 June 2011 IWIN Workshop 35

Europe moving to Smart Grid BUT

- Electricity and Gas embracing remote meter reading
  - But motivation is narrow and industry interest dominated
  - Example is British Gas use with GPRS and without Internet
- If they go Internet at all, use heavily NATs with IPv4
- Customers may want their own LAN-based system that includes all utilities, local generation and local control
  - This will need IPv6 for addressing and protocol reasons
  - If working with NATed IPv4 utilities, will require complex G/w
- It is not clear how this will evolve in Europe
  - For instance British Gas is NOW introducing “smart meters” which will use GPRS to utility, and special ZIGBEE to customer
- We pray that new start-ups will obsolete the majors

19 June 2011 IWIN Workshop 36

Emergency Communications

- U-2010 showed applicability of IPv6
  - Significant Luxembourg demo with fire, police & ambulance
- Some of the conclusions of the EC IP
  - Gateway to TETRA, but much better performance
  - Large-scale addressing of sensor networks
  - Capability of dealing with adhoc network
  - Ability to deal with security of sensor nets and media
  - Addressing size allows federation of different agencies on specific VPNs
  - Autoconfiguration allows easier set up of networks when infrastructur has been destroyed
  - Support for mobility in IPv6 particularly important

Emergency Communications Future

- Some Europeans very interested in U-2010 results
- Most concerned at the size of present deployments
  - Even IPv4 new to most
  - Strong pressure to deploy TETRA
  - Mobile operators interested in IPv6 mainly for IMS
- This is in spite of clear advantages of IPv6 for this application
- Requires relevant authorities to look at transition questions in the light of current TETRA deployments

Personal Communications

- Few VoIP and Conferencing systems fully IPv6
  - Though with scale envisaged, IPv6 would be needed
- Some Open Source products already enabled
  - ISABEL, VIC/RAT, Linphone, SIP-Communicator
    - Though not all completely IPv6-tested yet
  - OPENSER and ASTERISK have open-source IPv6 versions
- Less Commercial products fully available, but e.g.
  - Cisco has product (with limited protocol support)
  - Tandberg is IPv6 ready (and is now Cisco)
  - There Is still very limited inter-vendor testing

19 June 2011 IWIN Workshop 39

What should we do for Services

- Ensure backbone networks are dual stack
- Ensure your main servers can run dual-stack
  - Web, file, message
- Ensure your local infrastructure has dual-stack capability
  - Running via tunnels to other islands if necessary
- Evaluate major software systems you use are IPv6-ready
  - Ensuring new procurements have dual stack upgrade clauses
- Ensure that terminal equipment is IPv6-ready
- Start running dual-stack in your organisation
- Start running some IPv6 services – like conferencing or web
  - Using tunnels if other infrastructure not ready

19 June 2011 IWIN Workshop 40

What should we do for new Apps

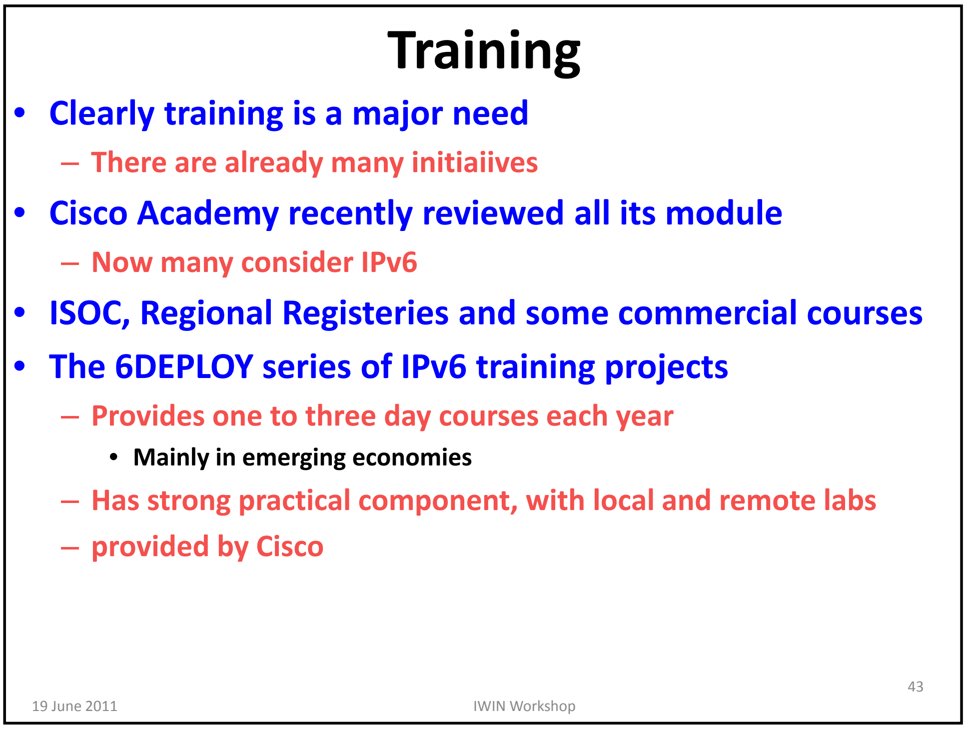
- Once you are running some sort of IPv6 infrastructure, it is worth exploring where advanced IPv6 features would help, e.g.
  - Mobile applications or ones with ad hoc nodes, where MIPv6, NEMO or MANEMO will be useful
  - Peer-peer applications, where you will run out of address space
  - Large-scale monitoring applications, where both large address space and 6LoWPAN will help
  - Emergency situations where the address space helps automated VPN construction, auto-configuration helps and the built-in IPv6 are particularly helpful

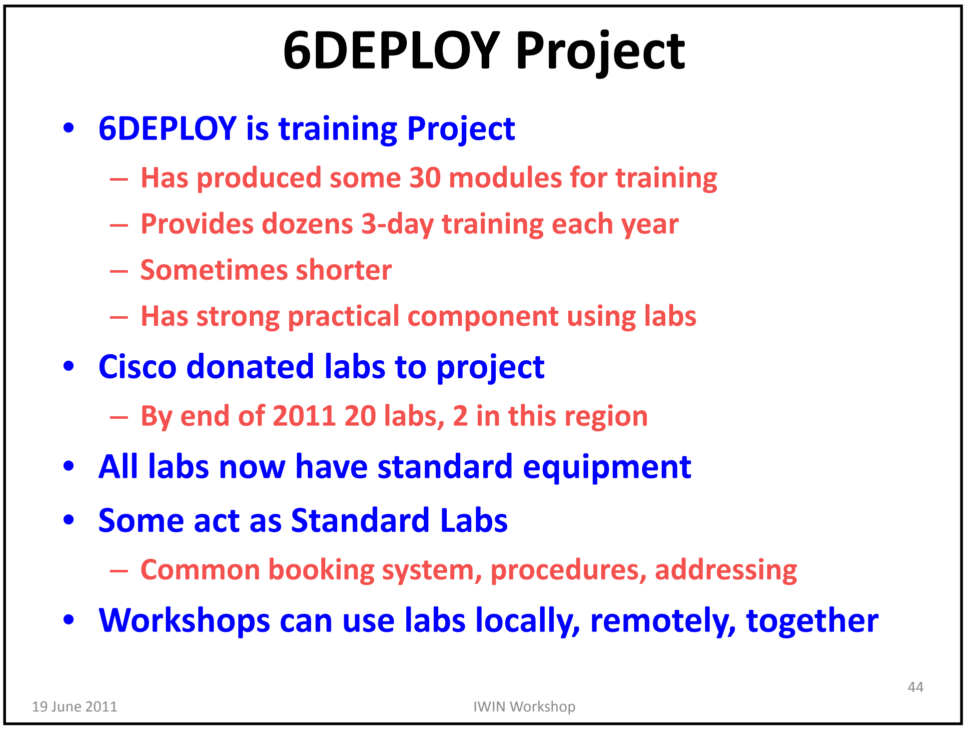
19 June 2011 IWIN Workshop 41

Contents of Talk

- The Internet and IPv4 and address depletion
- What is IPv6, and its advantages
- How near is transition to IPv6?
- New Protocols and IPv6 drivers
- Some important applications that would benefit
- *Training and 6DEPLOY*

19 June 2011 IWIN Workshop 42


Training
• Clearly training is a major need
– There are already many initiaiives
• Cisco Academy recently reviewed all its module
– Now many consider IPv6
• ISOC, Regional Registeries and some commercial courses
• The 6DEPLOY series of IPv6 training projects
– Provides one to three day courses each year
• Mainly in emerging economies
– Has strong practical component, with local and remote labs
– provided by Cisco
19 June 2011
IWIN Workshop
43


6DEPLOY Project
• 6DEPLOY is training Project
– Has produced some 30 modules for training
– Provides dozens 3-day training each year
– Sometimes shorter
– Has strong practical component using labs
• Cisco donated labs to project
– By end of 2011 20 labs, 2 in this region
• All labs now have standard equipment
• Some act as Standard Labs
– Common booking system, procedures, addressing
• Workshops can use labs locally, remotely, together
19 June 2011
IWIN Workshop
44

Intentions of Project and Labs

- The intention is to develop centres of expertise
- The labs are distributed regionally in order to encourage them to foster regional training
  - Are concentrating on emerging economies
  - Now mainly routers, with locally supplied PCs
  - soon also VoIP and Sensor nets
- Cisco provides hardware and software support
- 6DEPLOY provides an initial training workshop
- The intention is that the institutions quickly become self-sufficient and do their own training
- It is hoped that the labs will all cooperate strongly

19 June 2011 IWIN Workshop 45

New Features in Labs Planned

- Server-based software routers
  - Based on Cloud Computing
  - Will co-operate with physical routers
  - Will be able to use physical or virtual routes locally or remotely
  - Some will be provided in remote labs, some will be provided as a cloud for Internet use
- Developing some new applications areas
  - VoIP, Conferencing, Sensor Neworks
  - Standard Labs may be equipped with these in the future

19 June 2011 IWIN Workshop 46

Location of 6DEPLOY Laboratories

- Cisco has established laboratories in four continents
- Europe
  - Bulgaria (Sofia), Czech Republic (Prague), France (Paris), Hungary (Budapest), Slovenia (Ljubljana), Spain (Madrid),
- Asia
  - Georgia (Tbilisi), India (Bangalore), Kyrgyzstan (Bishkek),
- Africa
  - Cameroon (Yaounde), Egypt (Cairo), Ghana (Accra) Kenya (Nairobi), Mauritius (Ebene), Rwanda (Kigali)
- America
  - Columbia (Bogota),

19 June 2011 IWIN Workshop 47

Some Closing Thoughts

- The Internet is now all pervasive
- While it can no longer change in a revolutionary way, it will change hugely in an evolutionary one
- The next step must be IPv6
  - Transition has been slow, but must now speed up
- USA has led the provision of IPv6-based components
- However South and East Asia are leading the transition
- Some huge new applications *should* be based on IPv6
  - A combination of blinkered and short-term thinking may prevent this happening in some regions
- Training is vital everywhere for the transition
  - special measures are needed in emerging countries

19 June 2011 IWIN Workshop 48

Proposal and Implementation of Pseudo Push Using Network Subsystem and Task Execution for PC

Kazuaki Nimura[†], Hidenobu Ito[†], Yousuke Nakamura[†], Akira Shiba[†], and Nobutsugu Fujino[†]

[†]Fujitsu Laboratories Ltd.
4-1-1, Kamikodanaka, Nakahara-ku, Kawasaki, Japan
{kazuaki.nimura, itou.hidenobu, nkmr, shiba.akira, fujino}@ jp.fujitsu.com

Abstract -For the progress of Cloud computing, receiving a service from the Cloud 24/7 will improve the experience of PCs (personal computers) like that of smartphones today. At the same time, an issue of electric power comes to attention widely and increasingly. By putting a PC in lower power mode more actively, it can increase the sleep mode timing and can improve the electrical issue. However, this should not bring any degradation of the usability; otherwise, it cannot be accustomed user to the policy. In this paper, we propose a system that can send a task from the Cloud and execute the task at a PC whenever it is necessary, even though the PC is in sleep mode. Therefore, it is easy to live with the sleep state of PC because it will open up the task automatically, if needed. Hence, we prototypes the system that use a web application as a task and a pseudo push as a notification. Then, we evaluate it in a real field. As a result, the proposed system is found to be capable of executing the task in a timely manner. In addition, we confirm that the pseudo push can maintain the communication using little additional power consumption.

Keywords: PC, Push, HTML5, Application cache, Power consumption.

1 INTRODUCTION

Like a smartphone, it is desirable that PC remains connected to the network and receive services at all times. To receive network services, the PC needs to be powered on even when a user does not use it, such as during a meeting or at nighttime [1]. To reduce the power consumption more actively, a tool is provided by PC companies, which can set the power policy easily and put the PC in sleep mode for a short period when there is no activity. However, actively putting the PC in sleep mode may have an impact on business performance because it cannot access network among them. In addition to put the PC in sleep mode more actively, any degradation of user experience is not desired.

In this paper, we propose an architecture that can receive and execute a task whenever needed. The architecture consists of four functions: task provision, task notification, task preparation, and task execution. Task provision and task notification are functions included in the Cloud side. Task notification is realized with pseudo push by introducing a subsystem that works even while the PC is in sleep mode. It can help in informing a user regarding the incoming task from the Cloud.

We then prototype the system as the basis of the usage that smartphone sends a task which consists of a photo viewer programmed as a Web application and photo data. Here, we focus on the Web application because the Cloud technology has been widely used recently and many applications are provided as Web applications, such as HTML5 (HyperText Markup Language version 5) [2]. By using HTML5 as an application, it can provide a highly functional web application that is comparable with the native application and can provide the functionality of a locally executable task. As the execution environment, we use the Google Chrome browser [3] and Chrome OS [4] because of its improved compatibility with HTML5.

Moreover, we evaluate it in real field environment. The result shows that the PC subsystem can deal with pseudo push, even when the PC host is in sleep mode, by using an incoming message. In addition, it can provide low-power downloading and execute the application without user access. Although we introduced an additional dedicated hardware to receive services, it proves that it is effective in power consumption.

The remainder of this paper is organized as follows. In section 2, we summarize related works. In section 3, we present our architecture. In section 4, we show the details on the prototype implementation. In section 5, we show the results from the system evaluation, and finally in section 6, we state our conclusions.

2 RELATED WORKS

In this section, we summarize the related works from the aspect of wake function as described in Table 1.

To wake through a LAN (Local Area Network), a magic packet needs to be issued as an awakener, like Local server. The controllable area is basically the local area.

- An architecture that can wake PC and continue network services for PC is described in [5]. This work copies the host system's properties to the subsystem in Sleep mode.

To wake through a WLAN (Wireless LAN), the PC needs to ask a proxy or an AP (Access Point) to issue a magic packet. The controllable area is basically limited in the local area.

- Apple Inc. has implemented proxying as a wake-on-demand feature on their wireless network-attached storage devices and computers [6].

To wake through a WWAN (Wireless Wide Area Network), an SMS (Short Message Service) gateway or a push gateway is used. It is needed to deal AT-command to receive the message.

- About notification service, Intel Anti-Theft uses SMS as the notification message [7].

ISSN1883-4566

- Android Cloud to Device Messaging Framework [8] for Android phones and tablets use persistent connection by TCP (Transmission Control Protocol) and wake through the push gateway.
- How to establish a WWAN connection from a host system even when the subsystem has a network connection is described in [9].

Table 1: Types of network and wake for PC

Network type	Controllable area	Awakener
LAN	Local	Local server
WLAN	Local	Independent proxy, Access Point
WWAN	Wide area	SMS gateway

As far as we know, no feasibility study has been made on PC wake using the push gateway. The concept is briefly explained in this paper; however, the main focus of our research is dealing with the tasks.

3 PROPOSED ARCHITECTURE

In this section, first we will explain the issue, and then show the requirement to solve the issue, in addition propose architecture to meet the requirements.

3.1 Problem

The problem we are focusing on in this study is there is no mechanism that can send a task whenever needed while keeping PC in a low-power state as long as possible. The term of "task" in this paper means small job such as registration to an event through a network.

3.2 Requirements

The requirements to solve the problem statement are as follows.

(i) To have a function that can accept and send a task from the Cloud whenever necessary.
This corresponds to the phrase of "send a task whenever needed" in the problem statement.

(ii) To have a function that can notify a task to PC regardless of the power state of the PC.
This corresponds to the phrase of "while keeping PC in a low-power state as long as possible" in the problem statement because if there is notifying capability, PC can be in sleep mode.

(iii) To have a function that can prepare the task without waking up the PC.
Usually a powered on PC consumes much power and if the task can be prepared without waking up the PC, it will contribute to reducing power consumption.
This requirement corresponds to the same statement described in (ii).

(iv) To have a function to execute a task without user interaction and show the task to user.
This corresponds to the same statement described in (i) because if a task does not execute in PC, the cloud cannot receive the acknowledgement of "send a task".

By complying with these, a task can be transferred to PC anytime and the problem can be solved.

3.3 Architecture

To meet each requirement, we propose an architecture that consists of following functions, which are also shown in Fig. 1.

(I) Task provision: To fulfill requirement (i), a function that can provision a task, which will be transmitted to the PC, is introduced. As described later, a requester registers a task to this function.

(II) Task notification: To fulfill requirement (ii), a function that can notify task existence by messaging even if the PC is in sleep mode is introduced. For this, a network connection needs to be available anytime. The adequate communication technology changes depending on the usage of PC. If a PC is required only local network connection, for example, because of the large size, a communication technology that covers the local area can be used. On the other hand, if we expect mobility to PC, wide coverage of the communication needs to be hired.

(III) Task preparation: To fulfill requirement (iii), a function that can do background preparation even if the PC is in sleep mode to contribute to reduction in power consumption is introduced. There are two types of background service. One is a task that is needed to wake PC, and consumed the task by PC. Another is a task that is not needed to wake PC, and it can transact all in the background.

(IV) Task execution: To fulfill requirement (iv), a function that can provide and execute a task that is received even if the PC is in sleep mode is introduced. To translate the incoming task to an executable task takes an important role. Once PC turns on, a task is executed automatically or showed the existence to display.

By using those, PC can receive a task whenever from the Cloud. Therefore, even persons that are inexperienced in PC can receive a service easily. Then, it can contribute to improve the user experience of PC.

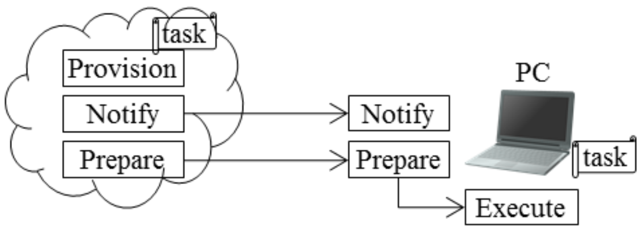


Figure 1: Proposed architecture.

4 PROTOTYPE IMPLEMENTATION

In this section, we will explain the prototype that realizes the proposed architecture and the task.

4.1 Prototype

Figure 2 shows the system structure of the prototype. The proposed system consists of the following hardware components: a requestor, task server, push gateway, host PC, and subsystem.

Requester:

There are two requesters. One is a requester that registers a task to the task server. Another is a requester that requests a push to the push gateway to send the task to the PC with the subsystem. It might be the requester is a corporate IT, for example. This component corresponds to the function (I) in the architecture.

Task server:

The task server carries out (I) task provision. It receives a task from the requestor, adds it to the repository, and exposes the repository included tasks to the Cloud.

Push gateway:

The push gateway carries out (II) task notification. It is designed that it can provide the service not only PC but also other devices such as smartphone and smart tablet. It consists of the following three elements that asynchronously work with each other.

- Push reception: A push message request is received from a pre-defined device such as smartphone, PC, or server.
- Push sender: It is responsible for sending a push message to the PC. It manages a persistent connection with the PC to deal pseudo push. If there is no connection between the push gateway and PC, for some reason, then it will resend the push message later.
- DB: It has information of PC identifications and requester identifications. When it receives a push request with a PC identification and requestor identification, the DB is checked whether the requester is preregistered and the PC identification is preregistered. If there are, it will serve.

Host PC:

The host PC cares the (IV) task execution, and it has the following elements:

- Browser synchronizer: It checks whether the web application or data exist in the SD memory and if there, correct through the memory. The timing of check is at the return from sleep or polling from the host system while it is in the power on state. A packaged application or data are reconstructed by this function. In addition, it injects the application or data to the browser cache. By doing this, the Web application or data can be used after the browser is initiated or reloaded.

Subsystem:

The PC subsystem carries out the counterpart of the (II) task notification and the (III) task preparation and it consists of the following elements:

- Push handler: It establishes a network connection with the push gateway. In addition, it receives a task notification. Besides, on, it analyzes an incoming push message. If it downloads or PC control requests, then the following functions are called.
- Downloader: If a push message has a download request, then it will download the Web application or data from the task server through the network to SD memory.
- PC control: If a push message has a PC control request, then it will issue a wake command to the PC with a condition. A condition might be nothing or wait until something happens. The example of a condition is whether the user is in front of the PC or not. If not, the request of wake will be pending, and if the user comes to the PC, then it will issue a wake to PC.

As mentioned above, these components can suffice the four pillars of the architecture. Therefore, by realizing the prototype, it can put the architecture into shape.

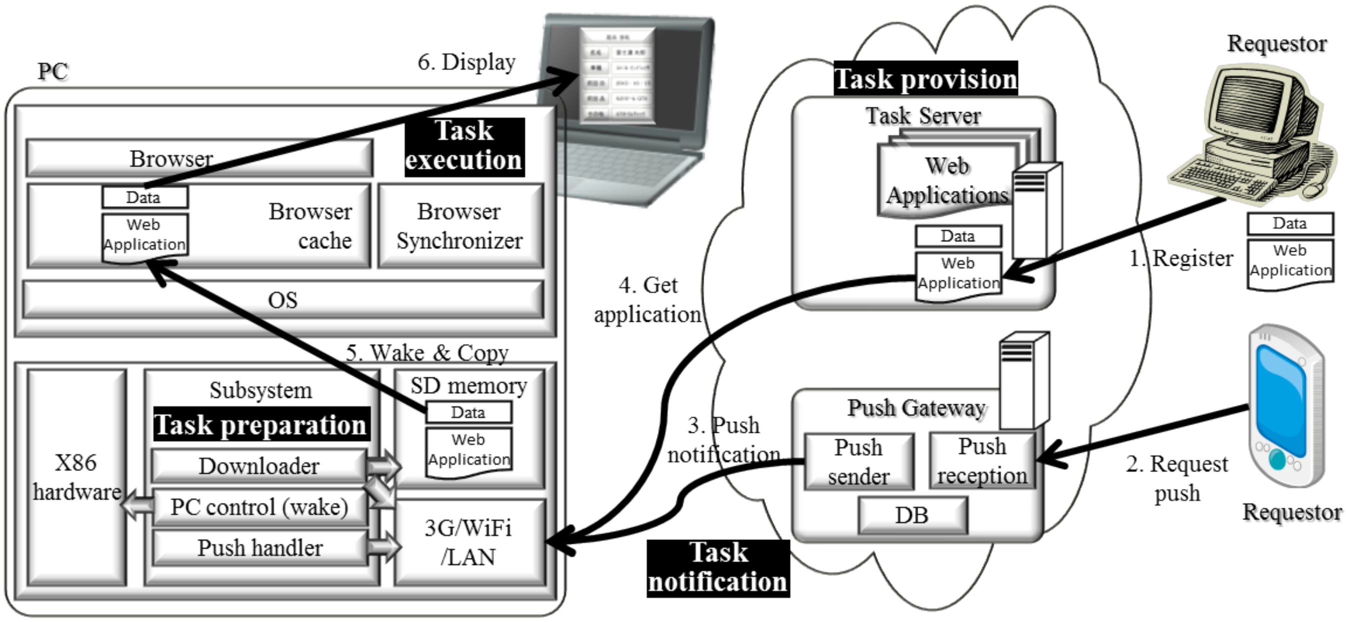


Figure 2: Prototype system.

4.2 Task and functions to deal task

To express a task, we use a HTML5 application and/or data. We will not exclude the local application though in accordance with the momentum of the Cloud computing, we focus on an HTML5 web application here. A HTML5-based Web application can be comparable with a native application because of its higher functionality than ever before. One of the curious features of HTML5 is the application cache. The application cache provides a capability to run the Web application in the local environment, i.e., even if the network is not available, you can still use the Web application. This is good for a person or corporate that needs to work in a restricted area, where the network connection is limited, for some reason, such as in a hospital. In this case, just before you get into that area, if you could receive the latest data from the Cloud service, you can use the application or data like a local application later.

Figure 3 shows an example of an HTML5 application. To use a locally accessible web application by HTML5, a list of resources needs to be specified below the line of "CACHE:" in a manifest file. By specifying it, you can use the application in a local situation.

When an application runs, basically, it first confirms the network connection at the runtime, and if there is a network connection, then it can act as conventional web application and access to the network as usual. However, if there is no network connection, it shall access to local application cache. Therefore, you can use the application anytime.

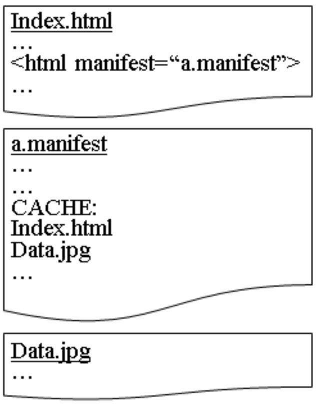


Figure 3: Web application with application cache

The detail of the four functions expressed in the architecture will be explained below.

Task provision:

Task provision provides a repository, which can store application and data for download.

Task notification:

Regarding the task notification for access to computing device anytime anywhere, there are two types of notification methods: polling and pushing.

- Polling: Polling is a method by which the client device accesses the server periodically. The disadvantage of polling is power consumption. An example of power consumption by a polling method has been shown in [10]. According to the explanation, when a TCP connection to the server is established, it consumes 5 to 8 mA. In addition, when the data are read, it consumes 115 mA, and when the data are written, it consumes 180 to200 mA. Then, a short polling consumes 0.5 mAh. If the information device polls every five minutes, it consumes 144 mAh. A typical battery for a smartphone gives 1500 mAh; therefore, about 10 % of the battery power will be consumed only by polling. Polling less frequently improves the efficiency, leading to less energy consumption. However, it loses the freshness.
- Push: Push is a way by which the server accesses the client when it wants to deliver some data. There are two types of push: true push and pseudo push.
  - True push: SMS or the type of messaging in Blackberry is categorized in this type [11]. SMS is a popular method for not only communicating between users but also initiating device management such as OMA DM (Open Mobile Alliance Device Management) [12]. OMA DM has a DM Server and a DM Client for the services. The DM Server can use a notification, and it is allowed to use an SMS-like message as a trigger to cause the DM Client to initiate a connection back to the DM Server. The problem of using SMS is that it can only accommodate a short size of information. For example, if you want to put a certificate in the SMS, it cannot accommodate that much information. E-mail notification is another method even though it has more than enough capability to control those computing devices.
  - Pseudo push: Pseudo push notification using persistent connection has been used to control smartphones or tablets. Basically, there is no limitation on the message size. Therefore, it can resolve the shortcomings of SMS.

We decided to use Pseudo push utilizing a TCP connection to notify a task. However, it has not been established for PCs yet. Then, we accommodated necessary capability needed for the client side in the subsystem, which works independently with the PC.

Task preparation:

Task preparation is a background function of introducing the subsystem, which means that it works independently with the PC.

Figure 4 shows the flow diagram for task preparation. First, the subsystem checks the attached network device and tries to connect through a valid network device. After it establishes a connection with the push gateway, it waits for the incoming push message. When a message comes, it analyzes the message whether it is valid message or not. If it is valid and the message is requested for download, then it will start downloading by accessing the given http address from the task server. If the message has a wake request, PC control function issues wake to the PC after the download is completed. It can be put an additional check before issuing a wake. For example, keep the wake request until the user approaches the PC, and if it detected by a sensor; it will issue wake to the PC.

Task execution:

Task execution works when PC is in on state. An added software function is the browser synchronizer. As shown in

Fig. 5, it checks the SD memory whether a valid application or data exist or not. If it exists, then it will reconstruct and inject the application or data to the browser cache and af terwards initiate the browser. Depending on the request in the push message, it initiates the browser. There are two types of view on the browser. One is displaying the application icons, and the user initiates an application implicitly. Another is running the application without user interaction.

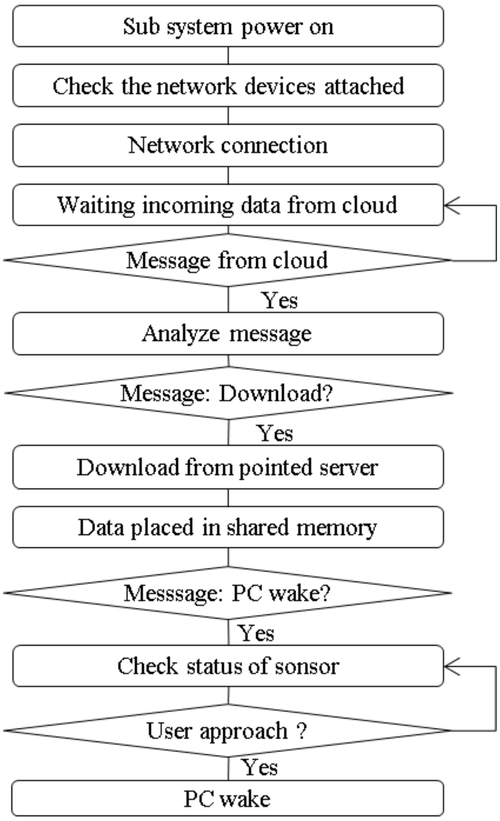


Figure 4: Flow of subsystem

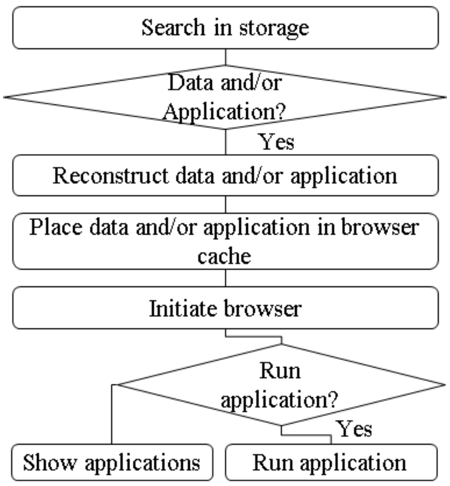


Figure 5: Flow of data collection and cache

5 SYSTEM EVALUATION

In this section, first, we show the hardware and software environments that are used for the evaluation, the result of the basic operation, and the measured power consumption.

5.1 Environment for System evaluation

Followings are the hardware and software configurations, which are used to evaluate the system.

Task Server:

- Hardware: A laptop computer is used as the task server and push gateway. It is a Fujitsu LIFEBOOK E780/A with an Intel Core i7 Processor 620M 2.66 GHz, 4 GB of main memory, and160-GByte hard drive.
- Software: A Web server is used as the task server. The public area of the server is used for placing an application and/or data. The requestor will place an application and/or data.

Push gateway:

- Hardware: One computer is used as the push gateway and task server. See above.
- Software: Linux is used as the OS. For the push reception, apache and Java Application Server (tomcat) are used. On the top of the Java Application Server, push reception is placed as a servlet. For the push sender, C-based program handles the communication with the PC. Between the two functions, those are communicating with a socket.

PC:

- Hardware: A laptop computer is used as the host system. It is a Fujitsu FMV-BIBLO NF/C80N, which had an Intel Core 2 Duo Processor P8600 2.4 GHz, 4 GB of main memory, and 80-GByte hard drive.
- Software: Three combinations are used as software environment as follows.
  - Microsoft Windows 7 as the OS and Google Chrome as the browser are used.
  - Linux as the OS and Google Chrome as the browser are used.
  - Google Chrome OS is used as the OS and the browser.

Chrome disk cache [13] is used as a place to put the Web application at all above.

Subsystem:

- Hardware: A Keil MCB2388 Evaluation Board is used as the subsystem. This has an ARM7 family-based processor. It also has a USB interface supporting USB devices and USB OTG/Host, SD/MMC memory card interface, and 10/100 Ethernet interface. The subsystem is connected to the host system through the USB device interface and to the network device through the USB host interface. In terms of electrical hardware specifications, the supply voltage of the board is 5.0 V and the typical current is 65 mA with the maximum current being 120 [mA] based on the specification sheet.
- Software: The board comes with RTX Real-Time Operating System, which allows programs that simultaneously perform multiple functions to be created. MDK-ARM Microcontroller Development Kit is a software-development environment that has a TCP Networking

Suite, USB device, USB host stacks, and other programming libraries.

Network devices:

- Hardware: Three network devices are used as follows.
  - A 3G communication device FOMA A2502 HIGH-SPEED is used as the network device. In terms of hardware specifications, the maximum downlink data rate is 7.2 Mbps and the maximum uplink data rate is 384 Kbps. It is bus powered through the USB port. The voltage is 5.0 V. The maximum current is 650 mA, the average current is 440.6 mA with the maximum standby current being 60 mA. The average standby current is 54.7 mA.
  - A LAN chip on the subsystem is used.
  - A WLAN device LANTRONIX WiPort, which supports IEEE802.11b/g, is used by connecting to the above LAN interface.
  -

5.2 Confirmation of basic action

We evaluated the system using the Google Chrome browser on Windows and Linux and Google Chrome OS. As a task, a Web application-based photo viewer and pictures are used. In the communication device, 3G, LAN, and WLAN devices are used.

Then, the following basic action is confirmed, as depicted in Fig. 6, based on the flow shown in Fig. 2.

Figure 6: Task send and execution.

(a) User takes picture using a smartphone. (b) User sends the data to the task server by e-mail. (c) The task server makes a package of data and an HTML5 photo viewer. In addition, the push gateway receives a push request from the phone, and pushes a message to the PC. (d) The subsystem receives the push message and downloads the application and data. Then, wake command is issued to the PC. (e) When the PC wakes, the application and data are injected to the application cache of the Google Chrome browser; finally, the web application and data are executed. At this moment, there is no network connection with host PC but subsystem. Therefore, it could confirm that the application is locally executed. Another simple basic action is confirmed as depicted in Fig. 7 and as follows.

(a’) User put a URL which shows a link to a HTML5 game application of a tool on PC and the tool register the app to the task server. Then it asks a push to push gateway with a message for execute the application. (b’) PC is in sleep. The subsystem receives the push message and downloads the application. (c’) PC wakes. The application is unpackaged. Then it is injected to application cache of the browser. Finally, a user can play.

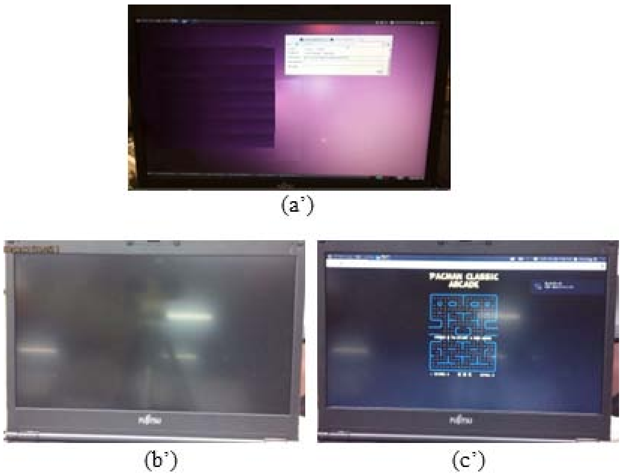


Figure 7: Task send and execution.

5.3 Measurement of power consumption

We will show the results of measurements of power consumption using the 3G module. First, we examine the persistent connection. Then, we compare the conventional PC and the PC in the proposed method. In addition, we will show the line of balance, which expresses how long the system should remain in sleep mode for reduced energy consumption.

How to put the PC in sleep mode is easy; the most used way might be timeout. It can be set in the operating system. If you specify a limitation time, and no activity has taken place at that time, the PC goes to sleep without any interaction. We have used this method to put the PC in sleep.

To express the power state, we refer the ACPI (Advanced Configuration & Power Interface) [14] that defines system and device power states. Some of them are as follows: S0 is in the system working state. S3 is a state in which the processors are not executing instructions and Dynamic RAM context is maintained. S4 is a state where the DRAM context is not maintained and all devices are in off state. S5 does not save any context. D0 is a state in which a device is in the operating state. D1 is an intermediate power state whose definition varies by the device. D3 is a state in which the device is powered off. If we use the term of "sleep" in this paper, then it implies that the PC is mainly in S3 but not exclude S4 or S5. If we express network device in D1, then it means that the network is connected but there is no communication.

5.3.1. Persistent connection.

We discuss the power consumption of a persistent connection in this subsection. We use a TCP connection to notify a task. Therefore, the power consumption of the persistent connection is a curious factor in terms of feasibility. It is expected that by using an open TCP connection without any transmitting or receiving of data, the power consumption will be low based on the standard hardware capability.

First, we measured the current of the subsystem that is in D0 (On), as listed in Table 2. Somehow, it does not match with the specification described in 5.1, and the result of actual measurement is more than that of the specification. For reference, the voltage is taken as 5 V. The evaluation board used as the subsystem has an unwanted device for the evaluation, such as an LCD; therefore, it can be a small value if we use the embedded CPU alone.

Table 2: Subsystem

Subsystem status	Current [A]
D0 (On)	0.152

Then, we measured the current of the subsystem with the network device as shown in Fig. 8, and the average current values are listed in Table 3.

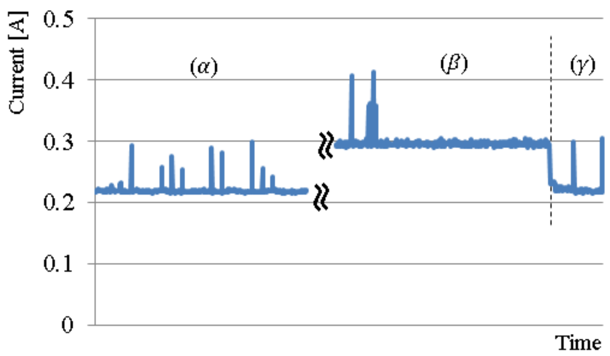


Figure 8: Measured current of subsystem with 3G.

The current changes until 60 sec and at 60 sec or later. As the device automatically transits to a low state when no explicit data are sent or received, the communication is maintained. The difference of current between the first row "plugged but not used for communication" and the third-row D1 in Table 3 is trivial. Even if the network is in communication ready, it does not consume a large amount of energy. This shows that a persistent connection can be fairly efficient in terms of power consumption. Comparing with the Table 2, difference between results given in Table 2 and the third-row D1 in Table 3 is 0.07 A, and it is found that the current is slightly high somehow when compared with the average standby current that is described in section 5.1. For reference, the voltage is taken as 5 V. This time, we use a product of a communication module for the PC, which started to sell in 2007. However, if we could use average type of communication device used in a cellular phone or M2M (Machine to Machine), the consumption will be around 1/8.

Table 3: Measured average current of subsystem with 3G

3G status	Subsystem status	Average current [A]
Plugged but not used for communication	D0	0.221…(α)
D0: Connected and idle (until 60 sec)	D0	0.296…(β)
D1: Connected and idle (60 sec or later)	D0	0.222…(γ)

5.3.2. Comparison of the conventional PC and proposed one.

We measured and compared the conventional PC and the PC used in the proposed method. Table 4 shows measurement result of average power consumption using the conventional PC with 3G. While the system is in S3, the absence of a network can considerably reduce the power consumption, which is well known.

Table 4: Without a subsystem: PC with 3G

PC status	3G status	Power [W]
S0: Idle	D0	26.45
S0: Http communication	D0	26.71
S3: Sleep w/o network	D3	2.030

Figure 9 shows the measurement results, and Table **5** lists the average power using the proposed PC with subsystem and 3G.

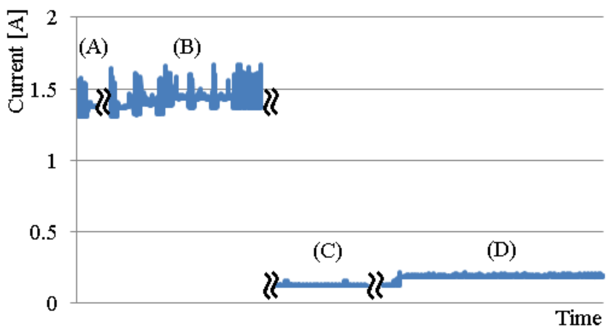


Figure 9: Measured current of proposed system.

The power consumption in S0 is almost the same. However, in S3, power consumption is slightly increased because of the communication capability. Figure 10 shows a border line derived using equation (10) in Appendix when T = 24 and based on the data given in Table 4 and Table 5. It shows whether the proposed system can provide the merit regarding the power consumption. The horizontal axis in the figure indicates the utilization time of the conventional PC, and vertical axis shows the bifurcation point, which indicates whether the proposed system is paid off. The left-hand side of the dotted line shows the invalid area. If it could increase the sleep time by reducing the time to go to sleep, then it can be reached to the line. For example, suppose you to use 12 hours per day currently, reducing 0.85 hour is the point matches to the current power consumption. If we could use a power-efficient subsystem and network device as described in the previous subsection, the borderline will move to much easier portion.

Table 5: With a subsystem: PC with a subsystem and 3G

PC Status	Subsystem status	3G status	Power [W]
S0: Idle	D0	D0	25.8…(A)
S0: Http communication	D0	D0	26.8…(B)
S3: Sleep w/ network	D0: Idle	D0	2.41…(C)
	D0: Http receive		3.55…(D)

This is strict and may not be so adequate to evaluate the merit because a computing device that is not networked cannot receive any crucial and valid service. Therefore, it might be accepted without any concern by the consumer even when additional power consumption is involved.

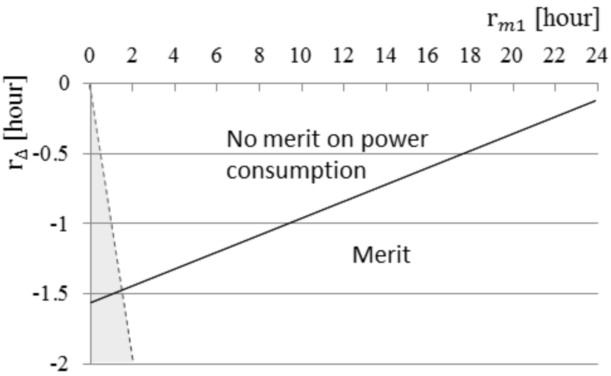


Figure 10: Line of balance of the proposed method.

6 CONCLUSION

We proposed an architecture where the system allows sending and executing of a task at any time in a PC. In our prototype implementation, we use a subsystem to keep network for dealing the pseudo push. In addition, we implemented a push gateway in the Cloud and a push handler and a browser synchronizer in PC.

The system could provide value that was not provided in current PC that:

- When a user wants to use the PC, the preparation is already completed.
- Task is presented to the user without user interaction.
- The power consumption can be reduced because during preparation, the PC can be in the sleep state.

In addition, we evaluated in real field using Google Chrome as the browser, Linux and Windows as the OS, and Google Chrome OS as the browser and the OS. For the network devices, we use LAN, WLAN, and 3G as the network devices.

Then, we confirmed that the system can send and execute tasks without user interaction even the PC is in sleep and pseudo push works efficiently in the power consumption point of view. From the measurements' data, the only small amount of additional power 0.001 [A] was required to deploy a connection for push.

With regard to the energy, as the subsystem is always powered, the lower the power consumption of the subsystem, more efficient is the system. The total power consumption per day would be comparable with conventional PC when if we could reduce the use of proposed PC 0.85 hour (suppose you to use 12 hours per day currently). However, the subsystem used in this study was not so efficient because of some glue logic. If we could use devices that eliminated wasteful logic or a new one, then the power consumption will be decreased.

In this study, we only focus on the PC. However, the same architecture can be used for embedded systems without any modification. In addition, the push gateway is designed to be an information device agnostic. Therefore, it can provide the push service to smartphone, smart tablet and other device as well.

As for the future research, remaining challenge might be how the system identifies the necessary task and the timing to push based on the activity of the users.

REFERENCES

[1] PC ENERGY REPORT 2009 UNITED STATES, UNITED KINGDOM, GERMANY, http://www.1e.com/energycampaign/downloads/PC_EnergyReport2009-US.pdf
[2] HTML5, http://dev.w3.org/html5/spec/Overview.html.
[3] Chromium an open-source browser project, sites.google.com/a/chromium.org/dev/Home.
[4] Chromium OS, http://www.chromium.org/chromium-os
[5] Yuvraj Agarwal, Steve Hodges, Ranveer Chandra, James Scott, Paramvir Bahl, and Rajesh Gupta, Somniloquy: Augmenting Network Interfaces to Reduce PC Energy.
[6] Apple Wake on demand, http://support.apple.com/kb/HT3774
[7] Introducing Intel Anti-Theft Technology version 3.0, http://antitheft.intel.com/Anti-Theft-30.aspx
[8] Android Cloud to Device Messaging Framework, code.google.com/android/c2dm/index.html.
[9] K. Nimura, H. Ito, Y. Nakamura, Z. Guo, K. Yasaki, and T. Miura, ``An Implementation of Transparent Network Subsystem for PC Manageability,'' RTCSA 2011, 17th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (2011).
[10] D. Ghosh, ``Building Push Applications for Android,'' Google I/O (2010).

[11] Simon Judge, What is Push?, http://www.mobilephonedevelopment.com/archives/832

[12] OMA Device Management Notification Initiated Session, www.openmobilealliance.com/Technical/release_program/docs/DM/V1_3-20101207-C/OMA-TS-DM_Notification-V1_3-20101207-C.pdf.

[13] Chromium disk cache, www.chromium.org/developers/design-documents/network-stack/disk-cache.

[14] Advanced Configuration & Power Interface, http://www.acpi.info/spec.htm

APPENDIX: FORMULATION OF POWER CONSUMPTION

In this section, we formulate the amount of electric power consumed by a conventional PC and the proposed PC, and then derive the equation of the line of balance. As described in Fig. 11, the proposed PC has an additional component called "subsystem," which is not present in the conventional PC. "Host system" is a main part of the PC. The subsystem affects the host system and the "network device." The network device is used for the communication. Each part consumes electric power.

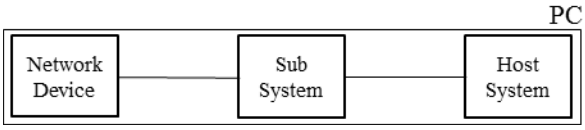


Figure 11: Proposed PC architecture.

Then, we formulate the power consumption as follows.

$$x_{on_{ave}} = \frac{\sum_{t=1}^{n_1}\left(v_c \cdot i_c(t) + v_h \cdot i_h(t)\right)}{n_1} \tag{1}$$

Here, $x_{on_{ave}}$ denotes the average electric power of a powered-on PC without a subsystem. n_1 denotes the number of measured points. t means the time at which the measurement is made. v_c denotes the voltage of the communication device. i_c denotes the measured current of the communication device at time t. v_h denotes the voltage of the host PC. i_h denotes the measured current of host PC at time t.

$$x_{slp_{ave}} = \frac{\sum_{t=1}^{n_2}\left(v_{h_{slp}}(t) \cdot i_{h_{slp}}(t)\right)}{n_2} \tag{2}$$

Where, $x_{slp_{ave}}$ denotes the average electric power of the sleeping PC without the subsystem. n_1 denotes the number of measured points. $v_{h_{slp}}$ denotes the voltage of the host PC in sleep mode. $i_{h_{slp}}$ denotes the measured current of host PC in sleep mode at time t.

$$r_{m1} + s_{m1} = \mathrm{T}\ [\text{hours}] \tag{3}$$

Where, r_{m1} denotes the time of on state of the conventional PC in one day. s_{m1} denotes the time of sleep state in the one day of conventional PC. T denotes the total amount of time in a certain period, such as a day.

$$X_{conventional} = x_{on_{ave}} \times r_{m1} + x_{slp_{ave}} \times s_{m1} \tag{4}$$

$X_{conventional}$ denotes the total electric energy of the conventional PC at certain time T.

$$W_{on_{ave}} = \frac{\sum_{t=1}^{n_3}\left(v_c \cdot i_c(t) + v_s \cdot i_s(t) + v_h \cdot i_h(t)\right)}{n_3} \tag{5}$$

Where, $W_{on_{ave}}$ denotes the average electric power of a powered-on PC with a subsystem. v_s denotes the voltage of the subsystem. i_s denotes the measured current of subsystem at time t.

$$W_{net_{ave}} = \frac{\sum_{t=1}^{n_4}\left(v_c \cdot i_c(t) + v_s \cdot i_s(t)\right)}{n_4} \tag{6}$$

Where, $W_{net_{ave}}$ denotes the average electric power of the sleeping PC with a subsystem that is connected to the network.

$$r_{m2} + s_{m2} = \mathrm{T}\ [\text{hours}] \tag{7}$$

Here, r_{m2} denotes the time of on state of the proposed PC in one day. s_{m2} denotes the time of sleep state of one day of proposed PC.

$$W_{proposed} = W_{on_{ave}} \times r_{m2} + W_{net_{ave}} \times s_{m2} \tag{8}$$

Where, $W_{proposed}$ denotes the total electric energy of the proposed PC in certain time T.

Obviously, adding the networked subsystem increases power consumption. Therefore, it is important to understand when it turns out to have merit. If we can put the PC in sleep mode for more time, then it can be paid.

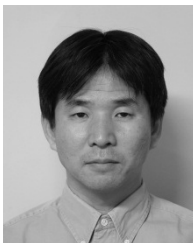
$$r_\Delta = r_{m1} - r_{m2} = s_{m2} - s_{m1} \tag{9}$$

r_Δ denotes the time difference between how much spend the PC on at conventional PC and proposed method.

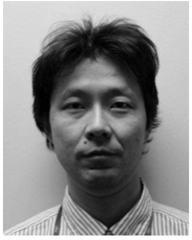
Consequently, the following formula can identify what time should the proposed system be kept in sleep mode than the conventional one if we wish to see the merit of the propose method.

$$r_\Delta \le \{x_{on_{ave}} \times r_{m1} + x_{slp_{ave}} \times (\mathrm{T} - r_{m1}) - W_{on_{ave}} \times r_{m1} - W_{net_{ave}}(T - r_{m1})\}/\{W_{on_{ave}} - W_{net_{ave}}\} \tag{10}$$

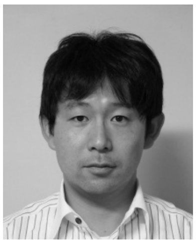
(Received February 27, 2012)
(Revised June 1, 2012)



Kazuaki Nimura received the BE and ME degrees in Graduate School of Information and Communication Engineering, Tokyo Denki University, Japan, in 1992 and 1994, respectively. He joined Fujitsu Limited in 1994 and transferred to Fujitsu Laboratories Ltd, in 1997. His current research includes advanced technology of smart device and human centric computing.



Hidenobu Ito received the BE and ME degrees in Mathematical Sciences from University of Osaka Prefecture, Japan, in 1991 and 1993, respectively. He joined Fujitsu Laboratories Ltd in 1993. His current research includes mobile computing and human centric computing.



Yosuke Nakamura received the BE and ME degrees in Graduate School of Engineering, Yokohama National University, Japan, in 2000 and 2002, respectively. He joined Fujitsu Laboratories Ltd in 2002. His current research includes advanced technology of personal computer and human centric computing.

Akira Shiba received the B.S. and M.S. degrees in electronics engineering from Sophia University in 1980 and 1982, respectively. He joined Fujitsu Laboratories Ltd. in 1982. Since then he has been engaged medical electronics and mobile computing, and is currently a Research Manager of human centric computing technology.

Nobutsugu Fujino received the B.S. and M.E. degrees in electronics engineering from University of Osaka Prefecture in 1984 and 1986, respectively. He joined Fujitsu Laboratories Ltd. in 1986. Since then he has been engaged radio communication systems and mobile computing, and is currently a research manager of human centric computing and multi device interaction technology. His research interests include mobile and ubiquitous computing and network applications. He received IPSJ Industrial Achievement Award in 2003. He received Ph.D. degree in informatics from Shizuoka University in 2008.

A Method for Modeling of Pedestrian Flow in the Space with Obstacles using Laser Range Scanners

Yoshitaka Nakamura†, Yusuke Wada‡, Teruo Higashino‡, and Osamu Takahashi†

†School of Systems Information Science, Future University Hakodate, Japan
‡Graduate School of Information Science and Technology, Osaka University, Japan
{y-nakamr, osamu}@fun.ac.jp, {w-yuuki, higashino}@ist.osaka-u.ac.jp

Abstract - The measurement of the pedestrians' movement has high utility, because many efficient services can be provided for pedestrians with the measurement data. There are some techniques to measure pedestrian traffic and especially the method to measure pedestrian traffic with laser range scanners attracts considerable attention recently. However, the lines of sights of the laser range scanners are obscured by obstacles. Therefore, it is difficult to completely capture all the pedestrians' movement in the target area. In this paper, we propose a method that estimates pedestrian traffic from sectional population density instead of individual pedestrians' data. Our method also generates pedestrians flow. We have evaluated the proposed method with ideal scenario data. The experimental results have shown that our method could reproduce pedestrian traffic with about 80% accuracy.

Keywords: Laser Range Scanner, Estimation of Trajectory, Pedestrian Flow

1 INTRODUCTION

With the recent development of the sensing technology, various phenomena can measured in the real world and the services using these measurement data become able to be provided. As such an example, Cyber Physical System attracts attention. The construction of the smart society by various services using various sensors becomes one of the new issues in the future information and communication technology. Among phenomena to be targeted for the measurement of the sensor, a tendency of the movement of the pedestrians (pedestrian flow) attracts attention recently. The information of pedestrian flow becomes important because this information in roads or the underground shopping center is available for the orientation of various services and the control of pedestrian flow.

For the mainstream method of the pedestrian flow measurement, there is the method that processes the images recorded by cameras, and tracks the pedestrian using the information. However, in the method using the camera, there are the privacy problem of target pedestrians and the problem of setting cost and the angle of view of cameras. In contrast, the measurement of the pedestrian flow with the laser range scanner attracts attention from a demand to measure the rough tendency of the pedestrian flow at low cost. The laser range scanner can scan a wide area fast. There is little fear to infringe the privacy information of pedestrian targeted for a measurement, because the measurement data which laser range scanner acquires are only positional information expressed as direction and distance for the scanner. In addition, the calculation cost is relatively small because the size of scanner data is much smaller than images. However, the laser range scanner is easy to lose sight of measurement objects by occlusion, and it is difficult to completely measure the all behaviors of all pedestrians in the measurement area.

In this paper, we propose the method for modeling pedestrian flow by estimation of the routes that the pedestrians would have passed not from the individual positional data of each pedestrian but from the population density at each division of the measurement area. In our method, the measurement area is divided in the division of constant size at first. Next, in each division, the number of pedestrians is counted using laser range scanner, and the population density in the division is calculated. Finally the course where pedestrian passed is estimated from the population density and generate pedestrian flow model. In this way, our method can generate the pedestrian flow model from the data that the all behaviors of all pedestrians are not observed.

2 RELATED WORK

2.1 Methods of measuring pedestrian flow

There are various methods to track the pedestrians. For example, a tracking method using images recorded by video cameras is often used. There is a method to measure pedestrian flow by recognizing the head of the pedestrians and tracking automatically using a stereovision camera. However, the measurement using cameras has much quantity of data, and the calculation cost becomes high. And from the viewpoint of privacy, the setting of the camera may be restricted.

There is another method to let each pedestrian hold the RFID tag which sends unique ID. This method estimates the position of each pedestrian from the position of the ID receiver and ID sent from RFID tags, and tracks pedestrians. However, for the tracking using the RFID tag, it is necessary to build the environment where ID receivers are deployed enough and to let pedestrians hold the terminal with RFID tag.

There is a method to estimate overall pedestrian flows from the flow quantity of each gateway by counting the passage number of people. However, if the instrumentations are affected by the occlusions, there is a problem that the numbers of the pedestrians who are not measured definitely increase as quantity of traffic increases. In addition, because only the number of passing pedestrians is measured, some behaviors such as stopping in the measurement area cannot be detected.

Some method using laser range scanners are proposed. Reference [1] measures the ankle of the pedestrian using scanners, detects walking rhythm of the bipedalism from the movement pattern of the ankle and tracks the pedestrian. However, in actual environment, this method may be influenced by the existence of the bag with the caster. Therefore it is necessary to devise measurement procedure.

2.2 Method of generating pedestrian flow model

The generation of pedestrian flow model is mainly used in the simulation of mobile wireless networks. Simple models such as Random Way Point Model [2] are often used for pseudo node mobility models. In late years some researches [3]–[6] to propose the mobility equal to subspecies of Random Way Point Model are performed. Many mobility models to compose realistic mobility by the measurement data and the geographical information have been proposed. Ref. [7] proposes the model to reproduce the interception of the radio wave by the buildings(obstacles), and the mobility model that nodes avoid those buildings. The method of Ref. [8] divides the simulation domain into some zones depending on the characteristic such as a residential area or a business district. And the method estimates the change of the density of every node classification by zonal unit using existing traffic planning method.

In Reference [9], Weighted Way Point Model is proposed. This method defines the domains with many people such as a cafe or the university, and models the movement of nodes between domains using Markov model by giving distribution of the sojourn time in each domain and the transition probability between domains. Time Slot Urban Pedestrian Flows model [11] estimates realistic movement routes on given road structure and derives the traffic quantity of each route to satisfy given density.

3 PEDESTRIAN FLOW MEASUREMENT USING LASER RANGE SCANNERS

3.1 Characteristic of the laser range scanner

A laser range scanner is the sensor which can measure the distance from a sensor to an object using the spread time of laser beam. And this sensor has characteristic to scan wide area fast. But, there is the fault to lose sight of the pedestrian targeted for the measurement when the pedestrian is hidden by the shade of obstacles such as pillars or different pedestrians(the occlusion problem). The laser range scanners which we used for pedestrian flow measurement is UTM-30LX [12] made by HOKUYO AUTOMATIC CO., LTD. Table 1 shows the specifications of this sensor. As for this sensor, the tracking of a pedestrian targeted for the measurement is possible [17].

3.2 Precedent experiment

A precedent measurement experiment was conducted in underground shopping center "Whity Umeda" of the neighborhood of subway Umeda Station of Osaka. We measured the pedestrians by synchronizing four UTM-30LXs. Figure 1 shows the measurement area and the installing position of the laser range scanners. The installed laser range scanners are expressed as the orange column of Fig. 1, the movable range of pedestrian is expressed with beige. The data measured by UTM-30LX are position coordinate data of the pedestrian in the measurement area every one second, and the unit of coordinate supports mm of the real world. In addition, specific ID is assigned to the pedestrian who appeared newly in the measurement area. While the tracking with the sensor succeeds, the identification of the same person is possible by this ID because the ID is unchangeable.

Table 1: UTM-30LX

Item	Spec
Detection Range	$0.1 - 30m, 270°$
Angular Resolution	$0.25°$
Scan Time	$25ms/scan$
Accuracy	$0.1 - 10m : \pm 30mm$
	$10 - 30m : \pm 50mm$
Size	$W60 \times D60 \times H87mm$
Weight	$370g$

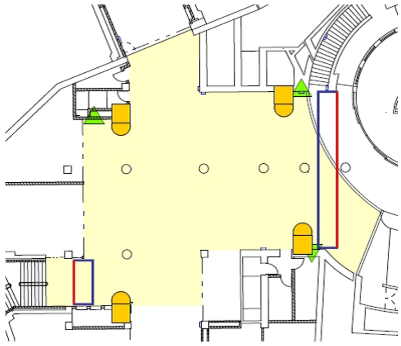


Figure 1: Installation position of laser range scanners

The data measured by UTM-30LX are following three.

- Measurement time: t
- Position coordinates of the pedestrian: (x, y)
- ID of each pedestrian assigned to by the tracking of the laser range scanners: i

After analyzing actual measurement data, the tracking in UTM-30LX is proved that it could continue only for a short time by the occlusion problem. The life time of the ID from 30% to 40% was approximately one second. It is caused by the following that a success period of the tracking shortens.

- A pedestrian is hidden behind obstacles such as pillars
- A pedestrian is hidden behind other pedestrians
- There are some pedestrian staying by the wall where sensors are installed and they narrow the measurement range of the sensor.

There are some methods to solve these problems. For example, they are methods to increase the number of sensors and method to use sensors which are not affected by obstacles. However, these methods have high cost.

4 PROPOSED METHOD

4.1 Overview

Because of the characteristic of laser range scanner, it is difficult to completely measure the behavior of all pedestrians when laser range scanners are used for measuring pedestrian flow. On the other hand, changes of pedestrian flow as the whole is regarded more important than each personal behavior in the scene where the pedestrian flow is used including trajectory analysis of customer in commercial facilities and pedestrian flow analysis for refuge instructions. In this paper, we pay attention to the change of the population density in the partial domain in the measurement area. Generally, the population density on the route that many people pass becomes higher, and population density changes along the direction of the pedestrian flow. Using this characteristic, our method extracts the characteristic of the pedestrian flow in the measurement area.

In our method, at first the measurement area is divided in the plural square domains of the equal size (unit cells), and the population density of each cell is calculated by the positional data of the pedestrian. From a tendency of the population density of each cell, our method estimates the cell which the pedestrians passed and estimates the routes of the pedestrians. The direction ratio of pedestrian via the estimated route is decided based on the directional information of pedestrian provided by the tracking with the laser range scanners. Our method expresses the number of pedestrians via certain route and the movement direction of the route in the form of the flow. This flow is the proposed pedestrian flow model.

4.2 Generation method of pedestrian flow model based on the population density

In this method, we use the measurement data and the tracking data of the laser range scanners for the measurement of the pedestrian. The tracking of the walker with the range scanner succeeds only for several seconds, 30% - 40% of IDs are measured only for about one second. Some pedestrians are expected to continue moving without being measured by sensors for a long period. Therefore to estimate the movement of the pedestrian we use the population density of the cells for certain constant period. The following assumptions are put for the movement of the pedestrian.

- Assumption 1 Pedestrians moves to the adjacent cell of top and bottom right and left from the cell which oneself is now.
- Assumption 2 Pedestrians move from the entrance to the exit without making a detour under Assumption 1.
- Assumption 3 Pedestrians are measured once in each cell which he/she passes.

The pedestrian flow model is generated in the following procedures.

1. Division to the unit cells of the measurement area
2. Choice of the gateway cells
3. Supposition of the route candidate between the gateways
4. Calculation of the population density of each cell
5. Calculation of the number of sojourners
6. Estimation of the route where the pedestrian passed and its traffic
7. Determination of direction of the flow

The details of each processing are as follows.

1. Division to the unit cells The measurement area is divided into cells like Fig. 2. Any size can set as the size of the cell. But it becomes hard to get the tendency of the movement of the pedestrian group as much as the size becomes large. And it costs for the calculation of the movement route of the pedestrian as much as the size becomes small. We assume the size of the cell 6.3m every direction in consideration of the speed of the pedestrian and the size of gateways.

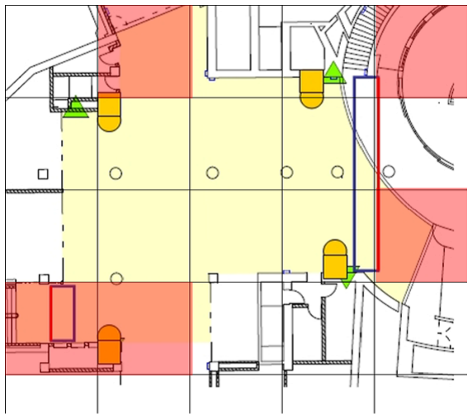


Figure 2: Target area divided into unit cell

2. Choice of the gateway cells We assume the cells in the border of the domain where sensors can measure and the domain where sensors cannot measure a gateway cells. The reddish cells are gateway cells in Fig. 2.

3. Supposition of the route candidate between the gateways For two different gateway cells, we assume a route between them as a route candidate. According to Assumption 1 and 2, we enumerate the route candidates for the combination of all gateway cells. Figure 3 shows the state to assume route candidates from two gateway cells. Yellowish green lines are the route candidates.

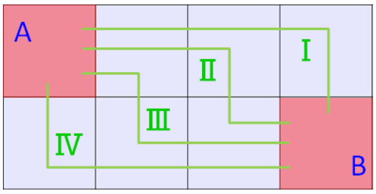


Figure 3: Assumption of route candidate

4. Calculation of the population density of each cell Using the measurement data of the laser range scanner for the constant period of time, the population density of the cells is calculated. Our method count it up how many pedestrians existed in each cell from the positional coordinate data of measured pedestrians during the measurement period (Fig. 4). Because the sizes of all cells are the same, the counted number of people is considered as the population density of the cells.

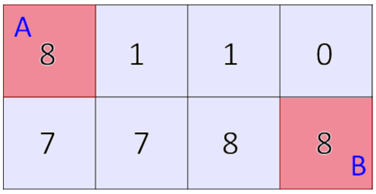


Figure 4: Calculation of density of cells

5. Calculation of the number of sojourners In the measurement area, some people may exist without moving (sojourners). By this method, the sojourners may be counted several times, and the population density of the cell where the sojourners are may grow large unnaturally, because sojourners are hidden behind other pedestrians. Therefore, it is necessary to exclude the data of sojourners not to influence the value of the population density. We set the minimum movement speed v_{min} for the pedestrian data succeeding for tracking, and exclude the measurement data of a pedestrian moving at a speed less than v_{min} at the time of the population density calculation.

It is necessary to know the number of sojourners because the control of sojourners is needed for the control of the pedestrian flow. Therefore our method calculate the mean number of sojourners during a measurement period based on the number of the pedestrians moving at a speed less than v_{min} which are excluded at the time of the population density calculation.

6. Estimation of the route where the pedestrian passed and its traffic The route that the pedestrian passed is estimated from route candidates and the population density of each cell. Pedestrian is less likely to pass the cell with the small population density and pedestrian is more likely to pass the cell with the large population density. From assumption 3, when one pedestrian passed a certain route, the population of the cell which the route passes increases 1. As a result, the population density also increases 1. Based on this assumption, our method calculate the route and the traffic, so that the population density of each cell calculated from the decided quantity of flow and the decided route becomes near to the population density of each cell really measured. Because there is much number of route candidates, and the calculation cost of verifying all combinations, we use the greedy algorithm for calculating the optimum route. The optimum route here is the route where the possibility that pedestrians pass is the highest when the population density of each cell was given. The criteria of the optimum route are as follows.

- Do not pass a cell with population density less than 0 as much as possible.
- Pass the cell which is high in population density with precedence.

The optimum route is calculated as follows by the greedy algorithm. At first, the most suitable route candidate for given population density is chosen as the temporary optimum route. The population density of each cell except the pedestrians via the temporary optimum route is calculated again. The optimum route is calculated by repeating the same process for the population density that updated a value. When one route corresponds to one pedestrian, the processing to remove pedestrians via the route corresponds to the process of reducing the population density of the cell which a route decided from Assumption 3 passes. When all the routes are decided and the population density of all cells became 0, the combination of I might calculate for the original population density might be calculated. Therefore the calculation by the greedy algorithm is repeated and finished when the total absolute value of the population density of all cells is minimized. The routes decided by the end of the processing expresses the course where each pedestrian passed. The number of each decided route expresses the number of pedestrians via the route. The route calculation processing is explained below by a specific example.

1. Calculate the most suitable course candidate as input by population density
   For example, the population density such as Fig. 4 is assumed input. The number of figures expresses the population density of the cell. The route candidates in this domain are I - IV of Fig. 3, and with the case of Fig. 4, route IV becomes the most suitable route candidate.

2. Check the total absolute value of the population density of all cells whether the most suitable route candidate may be chosen as a route
   The current total absolute value of the population density is 40, and the total value when the route candidate IV is chosen as a route is 35. Because the total absolute value of the population density becomes small, this route candidate is chosen as a route.

3. Output the value that updated the population density of the cell which the route passes
   Because one route corresponds to one pedestrian, the

population density of the cell which the chosen route passes is decreased 1. Route candidate IV is chosen in Fig. 3 as a route and Fig. 5 shows the value of the each cell is updated.

4. Return to (1) by the output in (3) as new input
The whole processing mentioned above is repeated by population density of Fig. 3 as new input.

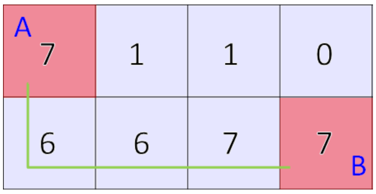


Figure 5: Population density when route IV is chosen

7. Determination of direction of the flow The information about quantity of flow and direction are necessary for pedestrian flow model. Therefore the direction of the pedestrian's movement via the route estimated from population density is needed. Because it is difficult to estimate the movement route of the pedestrian only from the positional coordinate data (x, y), we use the tracking function of the laser range scanners. The direction of the pedestrian's movement can be estimated from the position difference of an equivalence person provided by tracking while tracking succeeds. If a certain route p between gateway cells $g1$ and $g2$ are given, the direction of the pedestrian's movement in each cell which the route passes is examined. About a pedestrian moving along the route, the number of people according to a movement direction (someone move towards $g2$ from $g1$ and someone move towards $g1$ from $g2$) is counted. From the result of counting, the direction ratio of the pedestrian's movement is calculated, and the quantity of flow of the route is divided to accord with this ratio. In this way, the quantity of flow from $g1$ to $g2$ and the quantity of flow from $g2$ to $g1$ on the route p are obtained.

Figure 6 shows a specific example. The points in a figure express a pedestrian, and the arrows connected to each point express the direction of the pedestrian's movement. The long arrows between gateway cell A and gateway cell B expresses routes between A and B. The quantity of flow of the route is expressed by the number of the arrow. In the example of Fig. 6, the quantity of flow of the route between A and B is 3, and there are 3 walkers in each cell which the route passes. When the number of pedestrians is counted according to the direction of movement, the number of pedestrians toward cell B from cell A (the pedestrian with red arrow) is 10 and the number of pedestrians toward cell A from cell B (the pedestrian with blue arrow) is 5, because each pedestrian moves along the route. As for the direction ratio, the pedestrian toward B from A becomes 66.7% and the pedestrian toward A from B becomes 33.3%. Our method divide quantity of flow according to this ratio, and obtain a flow with 1 quantity toward A from B (blue arrow) and flows with 2 quantity toward B from A (red arrows).

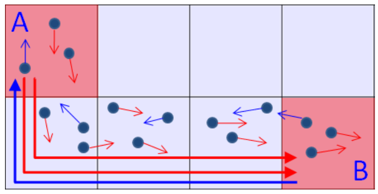


Figure 6: Determination of direction of the pedestrians' movement

The pedestrian flow model is generated in the flow form from the direction and quantity information of the flow by the above-mentioned processing.

From the measurement data which the experiment in "Whity Umeda" provided, the pedestrian flow models are as follows by the proposed method. The pedestrian flow model is generated from 10-minute measurement data until 8:26:08 a.m. on December 24, 2010 from 8:16:09 a.m. on December 24, 2010. The measurement area is a rectangular domain of $31.4m \times 27.7m$, and the size of the cell is $6.3m$ square. This area is divided in unit cells. The number of pedestrians who existed in each unit cell for 10 minutes is counted and this number is considered as the population density of pedestrians in each unit cell. To calculate an average flow per time, the quantity of the pedestrian flow is calculated from the population density that averaged the data for 10 minutes in the area for 1 minute. Figure 7 shows the population density of each cell obtained from measurement data.

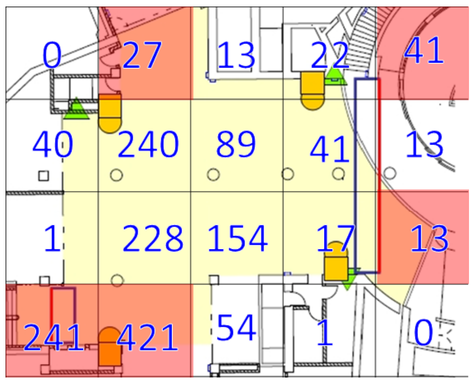


Figure 7: Population density (8:16:9 - 8:26:8)

Figures 8 and 9 show the pedestrian flow model generated from population density of Fig. 7. Figure 8 is a figure expressing each pedestrian flow from a certain gateway cell to a different gateway cell. Figure 9 expresses pedestrian flow of throughout the measurement area by expressing quantity of movement to the cell which is adjacent for each cell as arrows. The direction of the arrow is the direction of the pedestrian flow, and the quantity of the pedestrian flow is proportional to the thickness of the arrow. The numbers in figures expresses the number of the sojourners of the same cell for 1 minute. The movement speed v_{min} which is standard to judge a sojourner or a pedestrian is assumed $20cm/s$.

Furthermore, another pedestrian flow model is generated from the measurement data until 6:36:08 p.m. on December

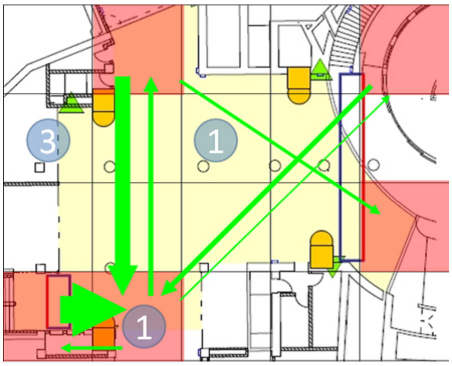


Figure 8: Pedestrian flow (Gateway to Gateway)

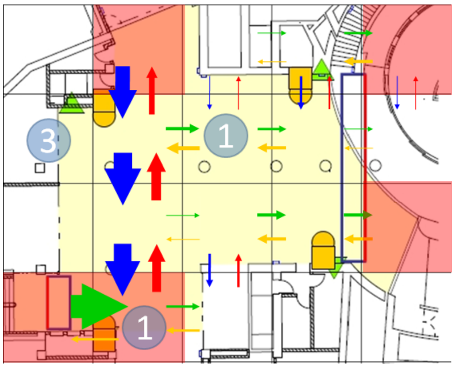


Figure 9: Pedestrian flow (Cell to Cell)

24, 2010 from 6:26:09 p.m. on December 24, 2010 on the equal conditions. Figure 10 and Fig. 11 show the generated pedestrian flow model.

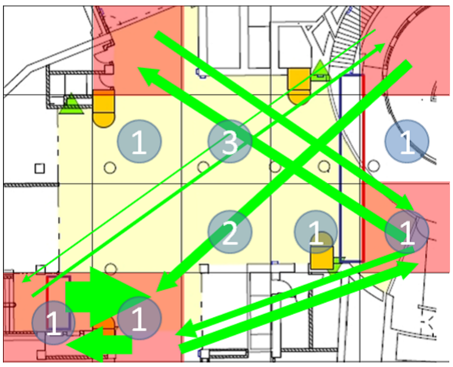


Figure 10: Pedestrian flow (Gateway to Gateway)

Because there are many people moving for commuting and attending school in the time of the morning, the characteristic flow that there is much movement quantity for the same direction is seen. People toward various directions are detected in the evening time. In addition, the existence of the sojourner is outstanding because there are many people to stop in open spaces such as the measurement area.

We also reproduced the people moved along flows based on the flow on Fig. 9 and Fig. 11, using MobiREAL Animator [13] realistically to output comprehensible animation data

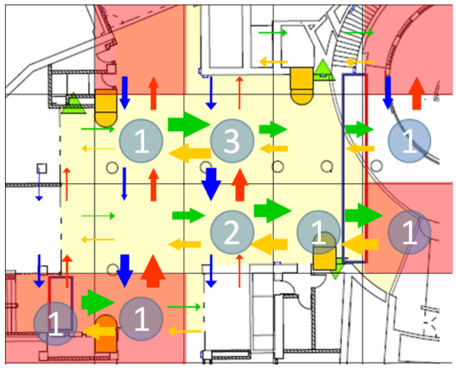


Figure 11: Pedestrian flow (Cell to Cell)

visually.

5 PERFORMANCE EVALUATION

Because of the failure in the tracking of the pedestrian by occlusion, the measured data which completely caught all pedestrians in the measurement area cannot be acquired using laser range scanners. Therefore, we artificially generate the scenario data which the behavior of all pedestrians can completely reproduced based on actual survey data by counting the number of people. And the pedestrian flow model is generated using the proposed method for this scenario data. By comparing this produced pedestrian flow model with the scenario data, we evaluate the reproducibility of the proposed pedestrian flow model to the scenario data. We compared the flow quantity toward exit cell g_2 from entrance cell g_1, and examined how much quantity of flow is reproduced.

The scenario data is generated from the data measured in ”Whity Umeda”. The position of gateway cells and the size of each cell make setting same as Fig. 2. Figure 12 expresses flows of the movement of pedestrian of the scenario data which made from the measured data of about 8:00 a.m. of December 24, 2010. The reddish cells in the figure are gateway cell (A - E), and the black arrow expresses the movement of pedestrians of scenario data. The thickness of the arrow expresses to the flow quantity of pedestrians. There are particularly many pedestrians moving between A - D or C - D in this scenario. We evaluate the precision of the proposed model for the state with many pedestrians who move to top and bottom, right and left for a cell by the index of the reproduction rate. The reproduction rate means the ratio that the flow generated by proposed method reproduces the flow of each route in scenario data. Figure 13 shows the comparison between scenario data of Fig. 12 and the flow quantity of routes linking each gateway cell of the generated pedestrian flow model. Though some false detection occurs, the average reproduction rate of the pedestrian flow quantity is about 82.9%, and pedestrian flow can be reproduced almost definitely by the proposed method.

Next, we evaluate the model using the scenario data which made from the measured data of about 6:00 p.m. of December 24, 2010. Figure 14 expresses flows of the movement of pedestrian of the scenario data. There are particularly many pedestrians moving between A - E or B - D in this scenario.

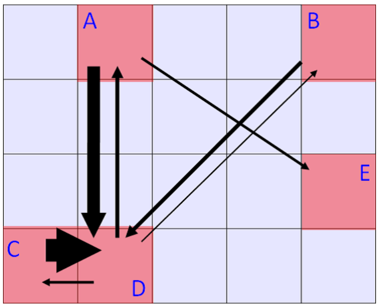


Figure 12: Scenario modeling from measured data in the morning

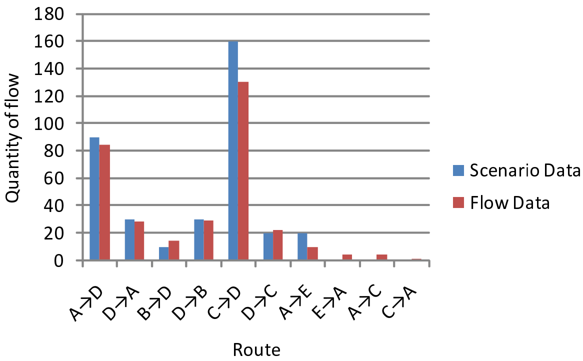


Figure 13: Comparing scenario data and generated flow

We evaluate the precision of the proposed model for the state with many pedestrians who move for a cell diagonally. Figure 15 shows the comparison between scenario data of Fig. 14 and the flow quantity of routes linking each gateway cell of the generated pedestrian flow model. The average reproduction rate of the pedestrian flow quantity is about 82.9%, and pedestrian flow can be also reproduced almost definitely in this case.

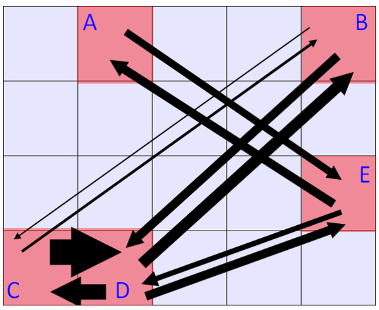


Figure 14: Scenario modeling from measured data in the evening

Finally, we evaluate the model using the scenario data which made from the measured data of about 1:00 p.m. of December 24, 2010. Figure 16 expresses flows of the movement of pedestrian of the scenario data. Pedestrians move to various courses in this scenario. We evaluate the precision of the proposed model for the state that there are the moving pedestrians to various courses at the same time. Figure 17 shows the comparison between scenario data of Fig. 16 and the flow quantity of routes linking each gateway cell of the generated pedestrian flow model. The average reproduction rate of the pedestrian flow quantity is about 59.6%. In this case, pedestrian flow cannot be reproduced definitely. It depends on the difficulty of the distinction of a pedestrian moving between C - E, B - C and a pedestrian moving between D - E, B - D respectively, because gate way cell C and D are adjacent.

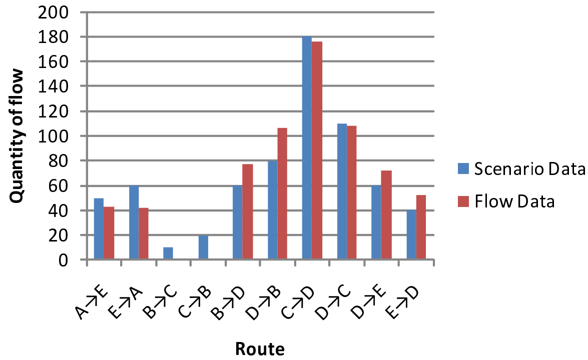


Figure 15: Comparing scenario data and generated flow

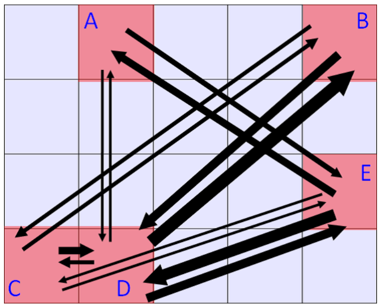


Figure 16: Scenario modeling from measured data in the afternoon

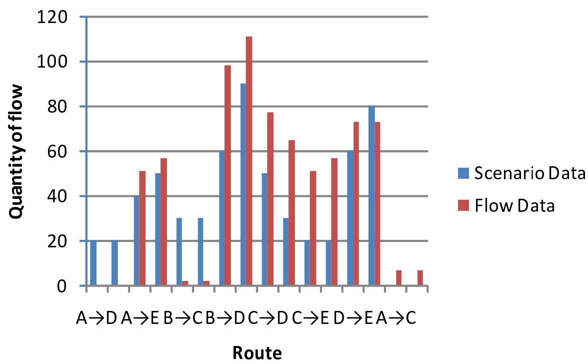


Figure 17: Comparing scenario data and generated flow

6 CONCLUSION

In this paper, we proposed the method for modeling of pedestrian flow in the space consisting of some gateways, some passages and various obstacles such as underground shopping center. The proposed method estimates the routes that the pedestrians would have passed not from the individual positional data of each pedestrian but from the population density at each cell of the measurement area. As a result, the proposed method can generate the pedestrian flow model from the data that the all behaviors of all pedestrians are not observed.

Future works include the model generation using the sojourner information of pedestrians, and the revision of the population density of each cell by the complement of the pedestrians who cannot observe by laser range scanner.

REFERENCES

[1] Huijing Zhao and Ryosuke Shibasaki, "A Novel System for Tracking Pedestrians Using Multiple Single-Row Laser-Range Scanners," IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, Vol.35 No.2, pp.283–291 (2005).

[2] Josh Broch, David A.Maltz, David B. Johnson, Yih-Chun Hu and Jorjeta Jetcheva, "A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols," in Proceedings of the 4th Annual ACM/IEEE International Conference on Mobile Computing and Networking(MobiCom'98), pp.85–97 (1998).

[3] Esa Hyytia, Pasi Lassila and Jorma Virtamo, "Spatial Node Distribution of the Random Waypoint Mobility Model with Applications," IEEE Transactions on Mobile Computing, Vol.5, No.6, pp.680–694 (2006).

[4] Christian Bettstetter, "Mobility modeling in wireless networks: Categorization, smooth movement, and border effects," ACM SIGMOBILE Mobile Computing and Communications Review, Vol.5, No.3, pp.55–67 (2001).

[5] Tommy Chu and Ioanis Nikolaidis, "Node density and connectivity properties of the random waypoint model," Computer Communications, Vol.27, No.10, pp.914–922 (2004).

[6] Andres Rojas, Philip Branch and Grenville Armitag, "Experimental validation of the random waypoint mobility model through a real world mobility trace for large geographical areas," in Proceedings of the 8th ACM/IEEE International Symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems(MSWiM2005), pp.174–177 (2005).

[7] Amit Jardosh, Elizabeth M. Belding Royer, Kevin C. Almeroth and Subhash Suri, "Towards Realistic Mobility Models For Mobile Ad hoc Networks," in Proceedings of the 9th Annual ACM/IEEE International Conference on Mobile Computing and Networking(MobiCom2003), pp.217–229 (2003).

[8] Matthias Hollick, Tronje Krop, Jens Schmitt, Hans-Peter Huth and Ralf Steinmetz, "Modeling Mobility and Workload for Wireless Metropolitan Area Networks," Computer Communications, Vol.27, No.8, pp.751–761 (2004).

[9] Wei-Jen Hsu, Kashyap Merchant, Haw-Wei Shu, Chih-Hsin Hsu and Ahmed Helmy, "Weighted waypoint mobility model and its impact on ad hoc networks," ACM SIGMOBILE Mobile Computing and Communications Review, Vol.9, No.1, pp.59–63 (2005).

[10] Minkyong Kim, David Kotz and Songkuk Kim, "Extracting a mobility model from real user traces," in Proceedings of the 25th IEEE International Conference on Computer Communications(Infocom2006), pp.1–13 (2006).

[11] Kumiko Maeda, Akira Uchiyama, Takaaki Umedu, Hirozumi Yamaguchi, Keiichi Yasumoto and Teruo Higashino, "Urban Pedestrian Mobility for Mobile Wireless Network Simulation," Ad Hoc Networks, Elsevier, Vol.7, No.1, pp.153–170 (2009).

[12] UTM-30LX, `http://www.hokuyo-aut.co.jp/02sensor/07scanner/utm_30lx.html`.

[13] MobiREAL, `http://www.mobireal.net/`.

[14] Ajo Fod, Andrew Howard and Maja J.Mataric, "Laser-Based People Tracking," in Proceedings of the 2002 IEEE International Conference on Robotics and Automation(ICRA2002), pp.3024–3W029 (2002).

[15] Dominik Joho, Christian Plagemann and Wolfram Burgard, "Modeling RFID signal strength and tag detection for localization and mapping," in Proceedings of the 2009 IEEE International Conference on Robotics and Automation(ICRA2009), pp.3160–3165 (2009).

[16] Jae Lee, Takashi Tsubouchi, Kenjiro Yamamoto and Saku Egawa, "People Tracking Using a Robot in Motion with Laser Range Finder," in Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems2006(IROS2006), pp.2936–2942 (2006).

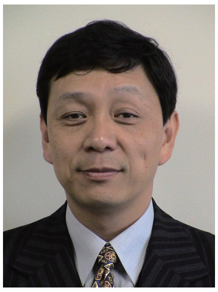
[17] Hirohiko Kawata, Akihisa Ohya, Shin'ichi Yuta, Wagle Santosh and Toshihiro Mori, "Development of ultra-small lightweight optical range sensor system," in Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems 2005(IROS2005), pp.1078-1083 (2005).

[18] Ryohji Ohba, Tomohisa Yamashita, Osamu Ukai and Shinsuke Kato, "Development of Hazard Prediction System for Intentional Attacks in Urban Areas," in Proceedings of the 7th International Symposium on New Technologies for Urban Safety of Mega Cities in Asia(USMCA2008), pp.687–696 (2008).

(Received February 27, 2012)
(Revised June 29, 2012)

Yoshitaka Nakamura received B.E., M.S., and Ph.D. degrees from Osaka University in 2002, 2004 and 2007, respectively. He is currently a research associate at the School of Systems Information Science, Future University Hakodate. He is a member of IEEE and IPSJ.

Yusuke Wada received B.E. degree in Informatics and Mathematical Science from Osaka University in 2011. He is currently a master course student at Graduate School of Information Science and Technology, Osaka University.



Teruo Higashino received B.E., M.E., and Ph.D. degrees from Osaka University in 1979, 1981 and 1984, respectively. He is currently a professor at the Graduate School of Information Science and Technology, Osaka University. He is Senior Member of IEEE, Member of IFIP TC6/WG6.1 and Fellow of IPSJ.

Osamu Takahashi received M.E. degree from Hokkaido University in 1975. He is currently a professor at the School of Systems Information Science, Future University Hakodate. His research interest include ad-hoc network, network security, and mobile computing. He is a member of IEEE, IEICE, and IPSJ.

Iterative Design of Adaptive Tabletop Dish Recommendation by Real-time Recognition of Dining Status

Tomoo Inoue[†]

[†]Faculty of Library, Information and Media Science, University of Tsukuba, Japan
inoue@slis.tsukuba.ac.jp

Abstract –This paper presents a series of smart dining tables named "Future Dining Table." The system recommends dishes to the user visually during dining according to his/her context. This is achieved by real-time recognition of the user's dining activity and the food remains, and by using its history. The system is supposed to be useful where repeated dish orders take place while the number of serve staffs is not enough. Evaluations are given in the recognition accuracies of eating action and food remains, which confirmed the system's practicality [1].

Keywords: Dining computing, Tabletop, Behavior recognition, Future Dining Table.

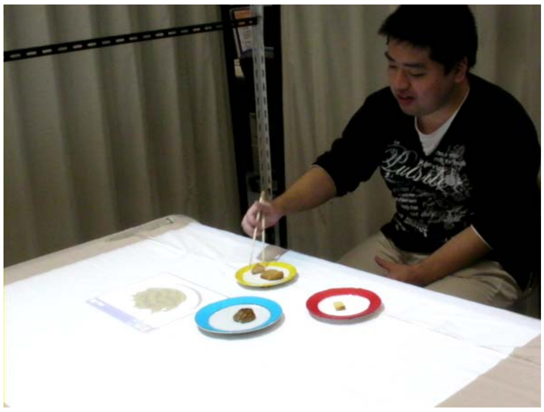


Figure 1: The system in use.

1 INTRODUCTION

Dining table, or the dining area, is a place where people get together and eat together. Regardless of whether it is at home or in public places, it is necessary for everybody because nobody can live without eating.

Information and communication technologies have become prevailing in many areas where we live. Dining table is one of the few places ICT would be deeply applied from now on.

We have been focusing on this research field as "Dining computing". We have applied the categorization of Computer Supported Cooperative Work (CSCW) to the dining computing and made the conceptual framework in 2007. In CSCW, the application areas are categorized in terms of time and space; "same time" or "different times", and "same place" and "different places." Because dining can be regarded as a kind of tasks, and dining together that involves multiple persons can be regarded as a kind of collaboration, the application areas of the dining computing can be categorized in the same way.

In this consideration, we can explore the key constituent of the dining computing applications. First, a typical CSCW application in "same time" and "same place" is an electric meeting room whose basic function is enhancing face-to-face meetings. So a typical corresponding dining computing application is a dining environment that enhances face-to-face dining. A smart dining table that understands the real-time context of the local users can be an application system of the category.

Second, a typical CSCW application in "same time" and "different places" is a desktop conferencing system whose basic function is providing a communication line when both users in different sites are in front of the cameras. So a typical corresponding dining computing application is a dining environment that connects users in different sites. A real-time tele-dining support system can be an application system of the category.

Third, a typical CSCW application in "different times" and "same place" is a physical bulletin board whose basic function is maintaining the connection between users in different times, e.g. by leaving a message. So a typical corresponding dining computing application is a dining environment that enables time-shifted communication and/or dining. Many families hold members with different living patterns and they sometimes have difficulty in finding shared dining time. This may be helped by such a system.

Fourth, a typical CSCW application in "different times" and "different places" is an e-mail system whose basic function is providing message transfer between users in different sites and times. So a typical corresponding dining computing application is a dining environment that enables time-shifted remote communication and/or dining. This may be useful for a family with some members live afar in different time-zones. It has the least constraints from time and space, but has least availability of live communication channels.

We call the dining environment in the dining computing "Future Dining Table," which includes all application systems of all categories. However not all the systems can be built at the same time. The adaptive tabletop dish recommendation systems that are presented in this paper are early application systems of the dining computing in real-time and face-to-face setting.

[1] The work reported in the paper was partially supported by the JSPS Grant-in-Aid for scientific research 22500104, the Research Grant of Telecommunications Advancement Foundation, and the Research Projects of Graduate School of Library, Information and Media Studies, University of Tsukuba.

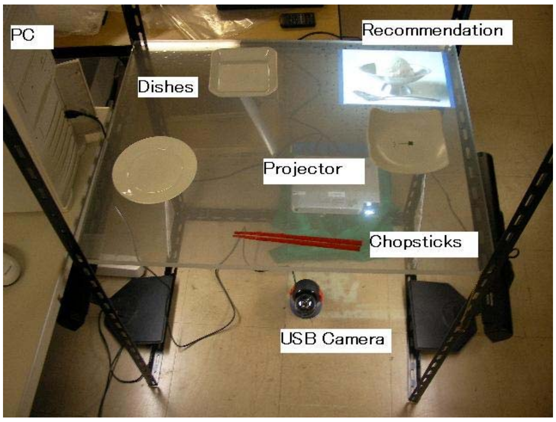


Figure 2: Appearance of the first FDT.

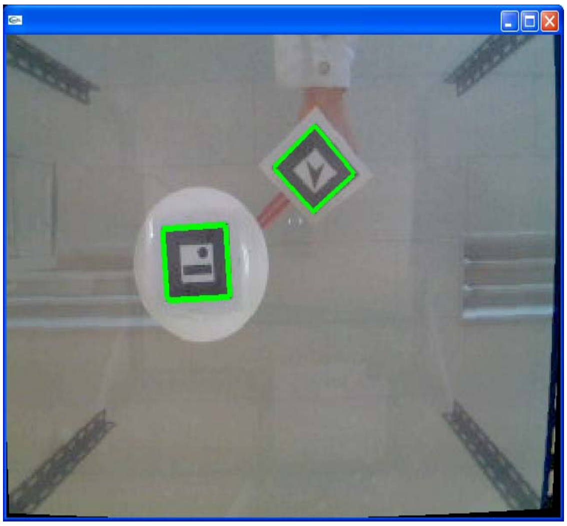


Figure 3: Visual markers on the bottom of a dish and on the user's hand.

So far, we have developed a few versions of FDT. It has evolved gradually. After the description of the related works in Chapter 2, this paper introduces those FDTs in Chapter 3 and Chapter 4. The system recommends dishes according to the dining status of the user (Fig. 1). The system has a USB camera as the input device, a PC as the information processing unit, a projector as the output device, and a table for dining and for information display.

In Chapter 5, the system's recognition accuracy of eating action was examined and compared to the previous system with different recognition method. The system's recognition accuracy of food remains was also examined in Chapter 6. These evaluations indicated the practicality of the system.

2 RELATED WORKS

There are other works in the dining computing besides our works.

The diet-aware dining table was a table that can track what and how much the users eat. To enable automated food tracking, the table was augmented with two layers of weighing and RFID sensor surfaces [1]. Although this table is a good example of the dining computing, it is not very easy to build such a special table. It is expensive and not portable.

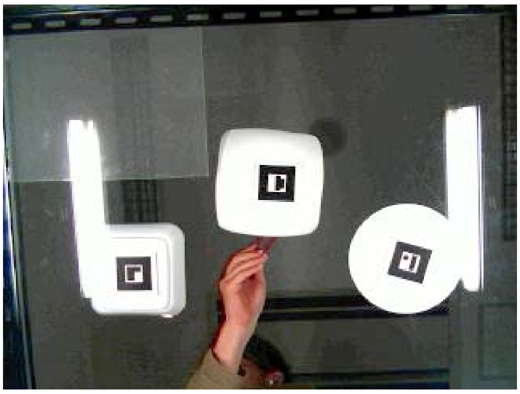
Then this table was applied to a dining game for better dietary behaviors of kindergarten children. The game was to color the picture of a child's favorite cartoon character. Each food item on the table corresponded to a particular crayon color, and the color would be drawn on the character when the corresponding food item was eaten. To make his/her favorite cartoon character colorful, the child was then motivated to eat and finish all the food items including those that he/she dislikes [2].

The Irodorin was a research prototype system that decorated a white dish plate with the projected colored light pattern according to the food color on the plate. This aims to make the food delicious [3]. This system was extended to the DiningPresenter, which showed drawings on and around a dish plate according to the food remains. The system also included the authoring tools in a kitchen [4]. This was for motivating children to eat up the food. The goal of the research was in this sense similar to [2]. The target user and the goal of our research in this paper is different, which aims to support the user's dining on the selection of dishes.

The pHotOluck was a system to help interpersonal communication during dining. It projected pictures on vacant dishes from above so that pictures gave clues to start conversation [5]. This research supports meal times in terms of communication but it does not use dining status or a user's behavior. We have also developed such a system for supporting communication [6], but this paper presents iterative design of FDT, which is unique with this system.

CoDine was a dining table embedded with interactive subsystems that augment and transport the experience of communal family dining. CoDine connected people in different locations through shared dining activities such as gesture-based screen interaction, mutual food serving, ambient pictures on an animated tablecloth, and the transportation of edible messages [7]. The goal of this research is to provide co-presence feelings for remote users, and this corresponds to the category of real-time tele-dining support systems. Another research on this category is Being Here System [8].

CU-Later was a system that played a recorded video of remote dining after a specific time shift when the local user was in front of the display placed on the dining table. So the local user could watch the video automatically when he/she was eating. The system recorded the local user's dining session as well when the video was played, so similarly the remote user could watch the local user's dining later on [9]. It is like a video mail exchange with automatic playback and recording. The goal of this research is to provide communication channels for the users in different time-zones, and this corresponds to the category of time-shifted tele-dining support systems. Another research on this category is KIZUNA system [10].



(a) Original image

(b) Extracted image

Figure 4: Hand recognition by image processing.

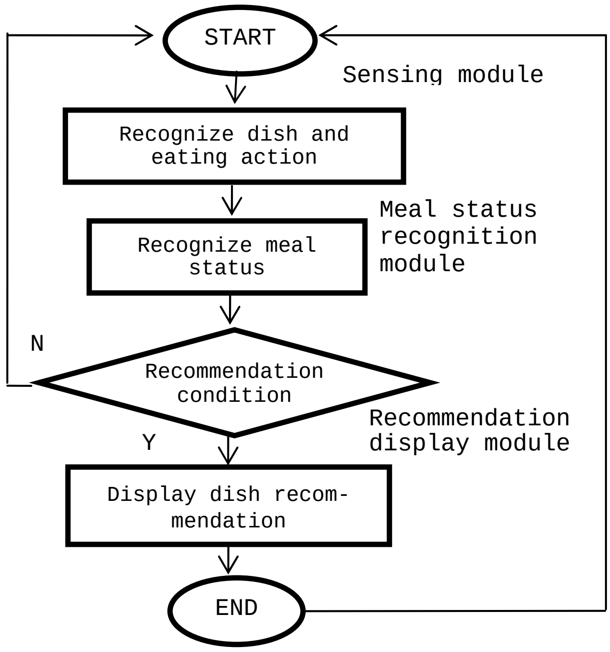


Figure 5: Software procedure.

3 FUTURE DINING TABLE

3.1 First Version

FDT is a tabletop system and recommends dishes according to the dining status of the user.

The appearance of the first version is shown in Fig. 2 [11]. The table was a transparent 15mm thick acrylic board with 60cm depth and 75cm width, sealed by the transparent screen sheet for video projection so that the recommendation can be displayed on the table. Each dish on the table had a visual marker on its bottom. The markers were recognized from the image taken by a USB camera under the table. The user also put the visual marker on his/her hand, which makes him/her feel unnatural (Fig. 3). The recognition was not very robust with the roll of the wrist. The marker was sometimes occluded.

3.2 Second Version

To prevent these problems, the user's hand was recognized by image processing in the second version [12]. The hand was recognized by the background subtraction method. The image of the table was captured first as the background. To cope with the gradual change of the shooting condition, every frame was combined at the rate of 0.01 with the background. To cope with the change of the dish location and the change of the recommendation image, the background was updated. It was replaced by the foreground image when the foreground remained the same in 50 consecutive frames. Then the background was subtracted from the current frame, and the changed region was gained. After the opening to delete minor noise, the region with some area (more than 1000 pixels) was extracted by the labeling (Fig. 4). This is the hand recognition process.

However, the same visual markers were still used on the bottom of the dishes with the transparent table, and the camera was under the table, which some users commented might be an issue. Also, the food remains were not measured directly from actual food.

3.3 Third Version

The third version has been modified to solve above-mentioned issues. A USB camera has been installed on the ceiling of the table and has recognized the dishes and the user's behavior. A white table has been used for the dining table with information display. A projector has also been installed on the ceiling of the table to project information on the table [13].

4 FDT SOFTWARE

The software of the FDT version 3 is explained in this chapter. It has been implemented by Microsoft Visual C++ on Windows OS. Figure 5 shows the procedure, which is constructed by the sensing module, the meal status recognition module, and the recommendation display module.

4.1 Sensing Module

Figure 6: Hand recognition from the ceiling.

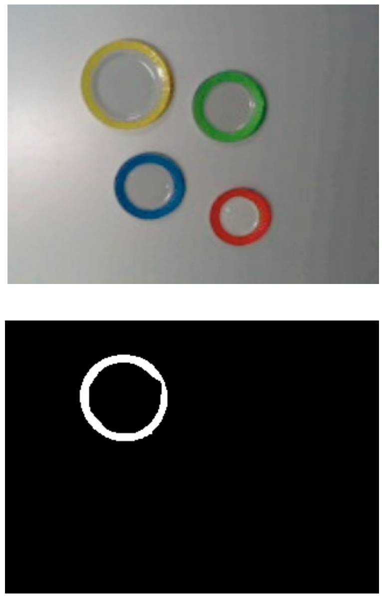


Figure 7: Dish recognition by colors.

The sensing module has been implemented with the Intel OpenCV. Four major processes are performed after obtaining the table image from the USB camera. They are hand recognition of the user, dish recognition, eating action recognition, and food remains recognition. When eating action is recognized, this triggers the meal status recognition module. When eating action is not recognized, the table image is replaced by its next frame. The frame rate of the camera is 9 frames per second.

Hand recognition

The finger tip of the user becomes most distant from the user's body and becomes close to the dishes on the table when eating action takes place.

The hand is recognized by the background subtraction method. The image of the table is captured first as the background. To cope with the gradual change of the shooting condition, every frame was combined at the rate of 0.01 with the background. To cope with the change of the dish location and the change of the recommendation image, the background is updated. It is replaced by the foreground image when the foreground remains the same in 25 consecutive frames. Then the background is subtracted from the current frame, and the changed region is obtained. After the opening to delete minor noise, the region that is more than 1000 pixels is extracted by the labeling. Figure 6 shows the hand recognition where the hand moves 23.3 cm/sec.

Dish recognition

The dish recognition is performed by the colors of the dish rims. Base colors of the round dishes are white with 5 different colors on the rims. The colored regions are extracted for each color and labeled to obtain the resulted region. Figure 7 shows the yellow dish recognition. The two points with the maximum and minimum x coordinates of the obtained region and the line between these two points can be gained. The line between the two points where the y coordinates are the maximum and minimum of the obtained region can be gained in the same way. The dish center can be gained as the intersection of the two lines.

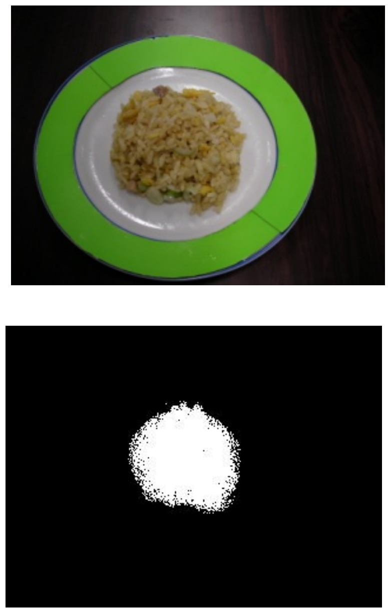


Figure 8: Food remains recognition.

Eating action recognition

Eating action recognition is performed by the distance between the dish center and the finger tip of the user. When the distance becomes less than the radius of the dish plus 10 pixels, it is determined that the eating action occurs empirically. It is because the user holds chopsticks with his/her hand but the chopsticks are too thin to get the image. The user picks up the food with the distance. Usually the system has multiple dishes on the table. If the finger tip becomes

Table 1: Example rules for the recommendation.

Status	Recommendation
Food remains is 25%	Closing food (Soba etc.)
Food remains is 5%	Desert (Ice cream etc.)
25% of 1st plate (Caesar salad etc.)	2nd plate (Gyoza etc.)
3 serial eatings of fries (Fried chicken etc.)	Same category plate (French fries etc.)
More than 6 drinkings (Beer) in the recent 10 eatings	Nibbles (Boiled soybeans etc.)

less than the "eating action" distances for multiple dishes in this case, it is treated the food is taken from the nearest dish. However this does not really happen because with the determined distance it is not realistic for the hand to occupy such a position.

Food remains recognition

One of the method to recognize food remains is to estimate from the number of eating actions [11][14]. This method needs the information of the number of eating actions to finish the dish. Then the food remains is estimated as the ratio of the current number of eating actions to that of finishing the dish. Because the number of eating actions to finish the dish can vary depending on the various factors such as individual, food, health condition, the estimation is not very accurate.

In welfare and medical care, meal has been recorded for management of health. This record is typically a written memorandum showing the given menu or sometimes the remains after meal. Because making a written meal record is time consuming and is not easy when there are many clients, automatic recording of meal has been researched. Recognition of video-recorded dining behavior is one such approach. Hand movement is detected and eating is recognized from the video of a dining room by applying hidden Markov model [15]. However, it does not recognize what the diners eat and the order of eating things.

Another method is to measure the weight of the foods. The food remains is calculated as the ratio of the current weight to the initial weight [1][16]. This method can be accurate but is not very easy to implement because the weight of each dish must be measured. Weight scales may be embedded to the dining table.

Our research employs image processing method. This method estimates food remains from the 2D images of the dish. The result may not be very accurate due to the use of 2D images, but may be obtained fairly easily and is directly based on the actual food.

Figure 8 shows the result. Non-white pixels are counted from the white dish area. This is compared to the number of the initial pixels and the rate is regarded as food remains.

Figure 9: Dish arrangement in the evaluation of eating action recognition.

4.2 Meal Status Recognition Module

Meal status recognition module receives the food remains for each dish and the eating action history. Then the meal status is estimated from these. The food remains basically show the whole progress of meal, while the eating action history shows more precise chronological food consumption trend. Any rule to recommend a dish from the combination of the food remains and the eating action history can be made.

Example rules have been implemented in the system as shown in Table 1. "Rule 1: Food remains are 25%," and "Rule 2: Food remains are 5%" are derived from the survey result of dish recommendation timing. Recommended dish was most felt like placing the order at 25% and 5% food remains in the survey. Also recommendation was least disturbing at 25% and 5% food remains [17].

4.3 Recommendation Display Module

After the meal status is recognized and the recommended dish at the time is determined by the recommendation rules, the recommendation is displayed on the table. The recommendation display module shows the image of the recommended dish dynamically depending on the existing dish positions.

The existing dish positions are known from the dish recognition. The recommended dish position can be determined in various ways and has been investigated. The positions that are near to other dishes and culturally right are known to be felt easy to eat [18]. The module uses this finding.

5 ACCURACY OF EATING ACTION RECOGNITION

5.1 Procedure

We have evaluated the accuracy of eating action recognition of the system. The same procedure was applied for the comparative evaluation to the first version which used the visual marker for the hand recognition and the current version which uses image processing for the hand recognition.

Table 2: Eating action recognition of the third version (%)

	Precision	Recall	F-measure
Subject A	78	88	82
Subject B	96	96	96
Subject C	100	75	86
Average	90	86	88

Table 3: Eating action recognition of the first version (%)

	Precision	Recall	F-measure
Subject D	95	79	86
Subject E	82	75	78
Subject F	68	54	60
Average	82	69	75

The subjects were three right-handed male university students. All were the first time users of the system. They were instructed to eat normally as in everyday. Three dishes were set on the table as shown in Fig. 9. A snack was chosen as the food on the dishes because the snack was of small pieces and we could control the number of eating actions easily. Eight pieces of the snack were set on each dish. This meant the subject conducted 24 actions. The behavior in the session was videotaped. The record of recognition by the FDT was compared with the videotaped behavior, which provided the correct answer.

5.2 Result

The results are shown in Table 2 and Table 3. Precision, recall and F-measure were used as the measures. These are originally from information retrieval, and have become generally used as the measures of such evaluation. Precision is defined as true positive / true positive + false positive. When an eating action from a false dish is recorded by the system, precision decreases. Recall is defined as true positive / true positive + false negative. When the system overlooks an eating action and does not record the action, recall decreases. F-measure is defined as the harmonic mean of precision and recall; F = 2 / (1/Precision + 1/Recall). It is used to represent the performance of both precision and recall in a single measure.

Because this type of evaluation is unique, we cannot discuss the results in comparison with those of other research. The precision was 90% and the recall was 86% on the average, resulting 88% of F-measure in the current version. Whereas the precision was 82% and the recall was 69% on the average, resulting 75% of F-measure in the first version. The change in the hand recognition method succeeded in improving the recognition rate.

Figure 10: Dishes used for food remains evaluation. (Top) Boiled soybeans. (Bottom) Fried rice.

6 ACCURACY OF FOOD REMAINS RECOGNITION

6.1 Procedure

We have also evaluated the accuracy of food remains recognition of the system.

The subjects were three right-handed male university students. They used FDT for dining. A single dish was served at one time. Two different dishes were served as shown in Fig. 10.

One was “boiled soybeans,” which each piece was not very small and the number of pieces was countable. The quantity was measured in pieces with this dish. We set 20 pieces initially, which means 5% decrease for every eating action.

The other was “fried rice,” which had different appearance from the former thus was expected to produce a different result. The quantity was measured by weight with this dish. A cooking scale with the minimum scale of 5g was used for weighting.

Both dishes were common in the supposed environment of the system. Each subject ate up these two dishes.

6.2 Result

The results are shown in Table 4 and Table 5. The remains recognition for fried rice was more accurate than that for boiled soybeans. The result of 5% in Table 4 shows the recognition bias clearly. The remains are recognized by the 2D image from the top. When the remains are recognized as 5%, the pixels of food are 5% of the initial pixels. This is only achieved when no overlapping of the food is found even if extraction of the pixels is accurate, and is often not realistic. In the experiment, only one piece of soybeans pod was 5% but the pixels for the one soybeans pod was clearly

Table 4: Food remains recognition for boiled soybeans (%)

	75%	50%	25%	5%
Subject A	60.0	40.0	10.0	0.0
Subject B	60.0	40.0	20.0	0.0
Subject C	75.0	35.0	10.0	0.0
Average	65.0	38.3	13.3	0.0

Table 5: Food remains recognition for fried rice (%)

	75%	50%	25%	5%
Subject A	53.3	46.7	30.7	5.3
Subject B	62.7	40.0	20.0	1.3
Subject C	73.3	60.0	37.3	9.3
Average	63.1	48.9	29.3	5.3

more than 5% of the initial pixels because the soybeans were piled up with overlapping on the dish. This is why the recognition of 5% always came after the actual 5%.

The reason why the difference in 75% was the biggest in Table 5 can be explained with the same recognition bias. Fried rice is also piled up on the dish. When the subject eats fried rice, he/she does not usually eat up a particular area, so does when eating a pizza. Instead, he/she often eats some upper part without finishing to the bottom. Because of the 2D image recognition, height decrease is not recognized, and the remains are recognized as the same in this case. Thus actual quantity becomes less than the recognized quantity by 2D image.

However, the differences between the recognized remains and the actual remains were within 5% when measured by the weight. Those two values were in good co-relation.

7 CONCLUSION

In this paper first presented the short introduction of the concept of the dining computing.

Second, a smart dining table system "Future Dining Table (FDT)" that has been developed iteratively for versions as an application system of the dining computing was explained. The system recognizes the user's dining activity and the food remains in real time, and along this context recommends dishes to the user visually on the table during dining.

Then the evaluations of the recognition accuracies of eating action and food remains were explained, which indicated the system's practicality.

According to the categories of the dining computing and other demands such as communication support, FDT will be further extended in the future.

ACKNOWLEDGMENT

This research was partially supported by the JSPS Grant-in-Aid for scientific research 22500104, the Telecommunications Advancement Foundation, and the Research Projects of Graduate School of Library, Information and Media Studies, University of Tsukuba.

REFERENCES

[1] K. Chang, S. Liu, H. Chu, J. Hsu, C. Chen, T. Lin, C. Chen, and P. Huang, ``The Diet-aware Dining Table: Observing Dietary Behaviors over a Tabletop Surface,'' LNCS, Vol.3968, pp.366–382 (2006).

[2] T. Lin, K. Chang, S. Liu, and H. Chu, ``A Persuasive Game to Encourage Healthy Dietary Behaviors of Young Children,'' Adjunct Proceedings of the 8th International Conference on Ubiquitous Computing (2006).

[3] M. Mori, K. Kurihara, K. Tsukada, and I. Shiio, ``An Augmented Table to Enrich Food Color,'' Proceedings of the 70th National Convention of IPSJ, pp.4-245-246 (2008). (in Japanese)

[4] M. Mori, K. Kurihara, K. Tsukada, and I. Shiio, ``Dining Presenter: Augmented Reality System for a Dining Tabletop,'' Supplemental Proceedings of the 11th International Conference on Ubiquitous Computing, pp.168-169 (2009)

[5] K. Nishimoto, K. Amano, and M. Usuki, ``pHotOluck: A Home-use Table-ware to Vitalize Mealtime Communications by Projecting Photos onto Dishes,'' Proceedings of the First IEEE International Workshop on Horizontal Interactive Human-Computer Systems, pp.9-16 (2006).

[6] S. Kutsuwada, and T. Inoue, ``Toward a System for Facilitating Multi-party Conversation Based on Dynamic Group Recognition,'' IPSJ SIG Technical Reports, Vol.2009-GN-072, No.6, pp.1-6 (2009).

[7] J. Wei, X. Wang, R. L. Peiris, Y. Choi, X. R. Martinez, R. Tache, J. T. K. V. Koh, V. Halupka, and A. D. Cheok, ``CoDine: An Interactive Multi-sensory System for Remote Dining,'' Proceedings of the 13th International Conference on Ubiquitous Computing, pp.21-30 (2011).
[8] M. Nawahdah, and T. Inoue, ``Building a high realistic media space by superimposing a remote person's figure on the local view,'' Proceedings of the 2012 IEEE 16th International Conference on Computer Supported Cooperative Work in Design, pp.416-422 (2012).
[9] H. Tsujita, S. Yarosh, and G. D. Abowd, ``Cu-later: A Communication System Considering Time Difference,'' Proceedings of the 12th international conference adjunct papers on Ubiquitous computing, pp.435-436 (2010).
[10] M. Nawahdah, and T. Inoue, ``Development of KIZUNA system to realize time-shifted virtual codining,'' Proceedings of the 6th International Conference on Collaboration Technologies, in press (2012).
[11] Y. Seto, Y. Noguchi, M. Tosaka, and T. Inoue, ``Development of Another Dish Recommender Based on Dining Activity Recognition,'' IEICE Technical Report, Vol.107, No.554, pp.55-60 (2008). (in Japanese)
[12] Y. Seto, Y. Matsusaka, and T. Inoue, ``Realtime Dining Activity Recognition in Another Dish Recommender,'' IPSJ SIG Technical Reports, Vol.2009, No.3, pp.1-6 (2009). (in Japanese)
[13] Y. Kourai, Y. Otsuka, and T. Inoue, ``Adaptive Tabletop Dish Recommendation System by the Recognition of Realtime Dining Activity,'' IPSJ SIG Technical Reports, Vol.2010-GN-77, No.18, pp.1-8 (2010). (in Japanese)
[14] Y. Dong, A. Hoover, and E. Muth, ``A Device for Detecting and Counting Bites of Food Taken by a Person during Eating,'' IEEE International Conference on Bioinformatics and Biomedicine 2009, pp.265-268 (2009).
[15] J. Gao, G. A. Haupymann, A. Bharucha and D. H. Wactlar, ``Dining Activity Analysis Using a Hidden Markov Model,'' Proceedings of the 17th International Conference on Pattern Recognition, Vol. 2, pp. 915–918 (2004).
[16] T. Kawashima, Y. Tanisugi, and Y. Mitsudo, ``Dining Monitoring System Using Sensing Tray and ID-ware,'' IEICE Technical Report, Vol.106, No.285, pp.61-66 (2006). (in Japanese)
[17] Y. Seto, and T. Inoue, ``Study of Recommendation of Dishes for a Dish Recommender System,'' IEICE Human Communication Group Symposium, HCG2009-C5-1 (2009). (in Japanese)
[18] Y. Otsuka, and T. Inoue, ``Comparative Study Of Attractive Dish Arrangements for a Tabletop Dish Recommendation System,'' Proceedings of 2011 IEEE International Conference on Systems, Man and Cybernetics, pp.357-362 (2011).

(Received March 8, 2012)
(Revised June 15, 2012)

Tomoo Inoue is Associate Professor of the Faculty of Library, Information and Media Science of University of Tsukuba. His research interests include HCI, CSCW, and CSCL. He received Ph.D. in Engineering from Keio University in 1998. He is a recipient of awards including Best Paper Award, Activity Contribution Award and SIG Research Award from Information Processing Society of Japan (IPSJ). He has served a number of academic committees, currently including IEICE SIG Human Communication Science, IEICE SIG Multimedia on Cooking and Eating Activities, VRSJ SIG Cyberspace, IPSJ SIG Digital Contents Creation, IEEE TC CSCWD, and IEEE TC HCI.

[Practical Paper] A Routing Metric towards Reliable Communication in Mobile Ad-hoc Networks

Katsuya Fuji†, and Takuya Yoshihiro‡

†Graduate School of Systems Engineering, Wakayama University, Japan
‡Faculty of Systems Engineering, Wakayama University, Japan
{s121048†,tac‡}@sys.wakayama-u.ac.jp

Abstract - MANETs (Mobile Ad-hoc Networks) have been studied as one of the future network technologies in which nodes construct a network autonomously via wireless communication. In MANETs, links are frequently cut due to node mobility or radio interference. To maintain the stability of users' communication, it is desirable to change communication paths to alternative ones before the paths become unavailable. To this end, several dynamic metrics are proposed so far for link-state routing protocols such as OLSR. They raise the metric of a link when its link quality decreases to avoid using low-quality links as communication paths. Those dynamic metrics, however, cause routing loops when the topology information at each node becomes inconsistent due to propagation delay of topology-change messages. Routing loops cause severe congestion so that it should be avoided. In this paper, we propose a new routing metric that is designed in order to ensure reliable communication against link cuts and routing loops. We evaluate the performance of the proposed routing metrics through simulation experiments. As a result, although we do not take the high-traffic-load effects into account, we confirmed that our metric works effectively in case of walking-speed mobility.

Keywords: Ad-hoc Networks, Dynamic Metrics, Communication Reliability

1 INTRODUCTION

Recently, wireless communications have been populated and wireless terminals such as smartphones are commonly used all over the world. Accordingly, as one of the next-generation communication technologies, wireless multi-hop networks such as MANET (Mobile Ad-hoc Networks) have been well studied. In MANET, because wireless links are not as stable as wired links, and also because node mobility frequently cut links, one of the key problems for practical use is how to improve the stability of communications. For this purpose, many studies have been conducted in the literature.

One of the major approaches to improve communication stability is to select links in forwarding paths as stable as possible using dynamic link metrics. In dynamic metric schemes, typically, lower metric values are assigned for higher quality links. By selecting a lower metric path as a forwarding path for each destination, we can significantly improve the throughput of networks. Various dynamic metrics have been proposed ever that consider several instability factors including communication speed, packet loss ratio, interference, mobility level, and so on [5]–[10].

Note that, in general, the objective of these proposals is to improve network throughput. However, in wireless multi-hop networks such as MANET, high network load causes congestion and even link cuts, which brings unexpectable behavior of traffic. Thus, to achieve reliable communication in MANET, we in this paper focus on route stability under dynamic metrics by excluding the effect of high load behavior.

In this paper, we concentrate on "link cut" due to node mobility, and "routing loops" due to transient inconsistency of network topology maintained at each node. By assuming that links are not cut by interference and physical obstacles, we can concentrate on these two factors (i.e., link cut and routing loops) as the cause of flow cuts of users. Note that even under this assumption, it is still difficult to realize reliable communication. Our trial in this paper is to examine whether dynamic metrics are effective to ensure reliability of communication against these two factors. Through investigating this point we try to get better understandings towards reliable communication over MANET.

More specifically, in this paper, we designed a new dynamic metric that is likely to work effectively against these two factors. In our metric design, we try to avoid link cuts due to node mobility, by controlling link metrics according to the distance between nodes using RSSI (Received Signal Strength Indication). Furthermore, to reduce routing loops, we apply methods called LMR[4] to our RSSI based metric. We evaluate our dynamic metric with several mobility scenarios to clarify the potential of dynamic metrics on communication reliability.

This paper is organized as follows: In Section 2, we shortly describe the related work of dynamic metrics in MANET. In Section 3, we describe the design of our dynamic metric for communication reliability. In Section 4, we evaluate our metrics through simulations, and finally in Section 5 we conclude the work.

2 RELATED WORK

2.1 Dynamic Metrics in MANET

Several dynamic metric schemes have been proposed in the literature. We first introduce the dynamic metrics for wireless mesh networks, in which nodes are stationary. One of the most widely known dynamic metrics is ETX (Expected Transmission Count)[5]. ETX of a link is computed as the successful transmission ratio of the link. Specifically, because a data transmission in wireless networks typically consists of a pair of "data" and "ack" frames, the ETX metric of a link

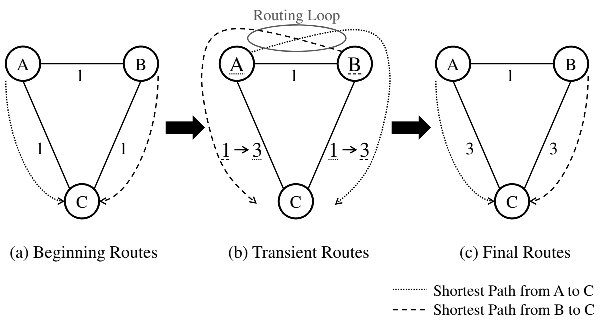


Figure 1: Example of Routing Loops

$l = (u, v)$ is defined as

$$\mathrm{ETX}(l) = \frac{1}{p \times q},$$

where p is the ratio of successful transmission of (u, v) and q is that of (v, u). In ETX scheme, nodes exchange periodical probe messages between their neighbors so that it is typically used in proactive routing schemes for MANET such as OLSR (Optimized Link-State Routing) [1].

As an extension of ETX, ETT (Expected Transmission Time) [6] was proposed, in which the average transmission time of a link is estimated by taking link speed into account. Because these two metrics (i.e., ETX and ETT) are computed based on the number of hello messages received in a certain time period, they have a drawback that they are not sensitive enough to handle mobility scenario. Although many other succeeding dynamic metrics for wireless mesh networks exist, (e.g., MIC (Metrics of Interference and Channel Switching) [7] takes interference among nodes into account), they all have the same problem of sensitivity when we apply them to mobility scenarios.

Several dynamic metrics for MANET with mobility are also proposed so far. In mobility scenarios, links connected to high-mobility nodes tend to be lost easily. Therefore, selecting links with low mobility nodes is essential for stable communication. Based on this idea, Yawut et al. proposed a node metric that estimates mobility levels of nodes [8]. However, to consider more specifically, relative speed between two nodes rather than speed of each node would be a more effective metric. Tickoo et al. computes relative speed between two nodes using RSSI (Received Signal Strength Indication) [9]. Furthermore, from the idea that the reliability of a path is determined by the lowest quality link of the path, Triviño-Cabrera et al. proposed a path metric to find the path with maximum least quality, which is computed based on RSSI [10]. They all, however, do not consider transient routing loops, which is also an important factor to consider reliability of communication.

2.2 The Routing Loop Problem

Routing loop is a problem that causes a severe instability of networks. The loops occur when a topology (including metrics) of a network changes. During the period of time until converging to the new routing tables, inconsistent routing tables computed from different topology create routing loops.

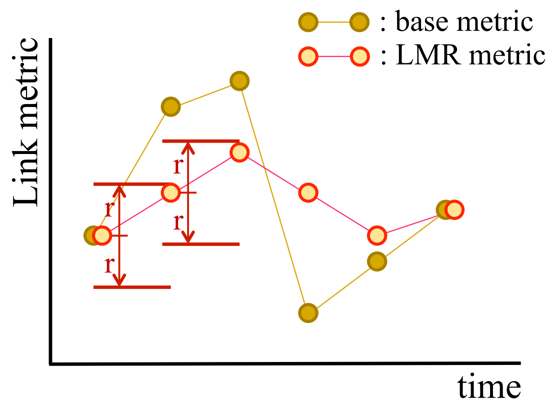


Figure 2: Reducing Routing Loops with LMR

See Fig. 1 for example. There are three nodes A, B, and C in the network. The metrics of links (A, B), (A, C) and (B, C) are all 1 at the beginning so that the shortest paths from A and B to C go directly to C (Fig. 1(a)). Assume that the metrics of (A, C) and (B, C) change to 3 simultaneously. It is natural that finally the shortest paths from A and B to C are the same as the beginning state (shown in Fig. 1(c)). In the transient state, however, routing loops are possibly created due to propagation delay, where A regards the metrics of (A, C) and (B, C) as 3 and 1, respectively, while B does those as 1 and 3, respectively. This state is shown in Fig. 1(b), where the dotted and broken underlines indicate the metrics that A and B know, respectively. Such routing loops frequently occur in ad hoc networks and cause severe congestion and communication disruption due to heavy packet loss.

As for the harmful effect of routing loops, Speakman et al. [14] reported that the loops cause severe congestion in MANET, and they proposed the technique to detect and suppress (i.e., drop) looping packets, which brought about 20% improvement in packet delivery ratio in a mobility scenario.

2.3 Dynamic Metric to Reduce Routing Loops

There are a few dynamic metrics in the literature that are aware of routing loops. The first loop-aware routing metric would be LLD [3], which constantly reduce link metrics little by little as time passes to prevent routing loops. LLD is based on the idea that the links with long living duration would be considered stable. Therefore, the link metric is designed depending on link duration. LLD, however, has a limitation that it cannot handle fluctuation of wireless link quality since the metrics monotonically decrease as time passes.

As another loop-aware method, LMR (Loop-free Metric Range) was proposed [4]. LMR can be applied to other dynamic metric scheme to reduce routing loops by limiting the amount of metric change per unit time. LMR defines a variable $r(> 1.0)$ called *metric stretch*, which limits in ratio the range of the next metric value to take. That is, $m_{old} \cdot r^{-1} < m_{new} < m_{old} \cdot r$ must be held, where m_{old} is the current metric of a link and m_{new} is the new (i.e., updated) metric. Note that, because LMR assumes a link-state routing scheme, link metrics are updated periodically when topology advertisement messages (TC messages in case of OLSR) are sent.

At each of the metric updates, if the new metric of the base dynamic metric scheme is out of the range, LMR uses the new metric with the nearest value in the range. The behavior of LMR described above is illustrated in Fig. 2. This figure shows the transition of the base metric, and the LMR metric that follows the base metric within the range of the metric stretch r.

As theoretical results of LMR [4], the value of r exists that guarantees loop-freeness under the assumption that no control packet are lost. Note that the value of r to guarantee loop-freeness depends on several values, i.e., the upper and lower bounds of link metric values m_{max} and m_{min} (we need to set these values to use LMR), and the network diameter w that is measured with hop count. Consequently, once m_{min}, m_{max} and w are given, the value of r to guarantee loop-freeness is determined.

Unfortunately, however, the value of r to guarantee loop-freeness is too small in general (e.g., the value is 1.002 when $m_{min} = 1, m_{max} = 5$ and $w = 10$ [4]), so we have to use larger values. To evaluate the loop reduction effect of LMR, we conducted a simulation experiment [4] using a network simulator Qualnet [13]. In the simulation, we prepared a 5×5 grid topology of stationary nodes and transmitted four UDP flows. As a result, the effect of LMR to reduce routing loops is clarified. Note that when r gets smaller, we can expect more effects on reducing loops whereas the effect of base dynamic metric scheme is limited because the dynamism of metric change is reduced. There is a trade-off between them so that we have to pay attention to the balance to work with optimal performance.

3 DESIGN OF ROUTING METRICS FOR RELIABLE COMMUNICATION

3.1 The Concept

We designed a dynamic metric that is aware of both link cuts due to node mobility and routing loops due to route inconsistency. To prevent disruption of users' communication caused by link cuts, we have to raise a link metric before the link is cut due to node mobility. That is, the routing metric must be sensitive to detect the symptom of link cuts. Note that, for this purpose, it is not suitable to use packet loss statistics like ETX because it requires long-term observation of probe packet transmissions to compute metrics, which means that this approach cannot trace the link quality sensitively.

In our metric design, we use RSSI (Received Signal Strength Indicator) values measured with hello messages transmitted by neighbor nodes to compute a sensitive routing metric. Specifically, we estimate the distance between two nodes using RSSI, and the link metric is computed according to the distance. Note that the distance estimation algorithm we use in this paper is quite primitive so that they might work surely only in simulations. However, we can use more practical distance estimation algorithms such as [11] when we apply our metrics in practice. Furthermore, because localization methods are also progressing day by day, if these methods achieve high accuracy localization, high accuracy distance estimation would also be possible.

On the other hand, to prevent routing loops, we apply LMR into our RSSI based routing metric. Note that LMR limits the effect of dynamic metrics instead of reducing routing loops. To take the balance of them, we have to select carefully the value of the metric stretch r.

3.2 Design of RSSI based Dynamic Metrics

The formula to compute the link metrics from the node distance should be carefully designed. In Fig. 3(a), we illustrate the case in which the distance between nodes A and C is approaching to the communication range. In this case, $A \rightarrow B \rightarrow C$ is the desirable communication path from A to C because the link (A, C) is about to be cut. Therefore, the condition $m(A, C) > m(A, B) + m(B, C)$ should hold, where $m(A, C)$ is the metric of link (A, C). On the other side, Figure 3(b) illustrates another case where the distance between A and C is far shorter than the communication range although the shape of node location is the same as Fig. 3(a). In this case, the desirable communication paths from A to C is $A \rightarrow C$, which reduces the hop count that packets travel. This means that the condition $m(A, C) > m(A, B) + m(B, C)$ is desirable in turn.

The above discussion means that the desirable paths depend on the distance among nodes, and the longer links should have higher metrics. To meet this constraint, we designed our link metric function as convex function. In this work, we use a simple polynomial convex function as a metric function.

The mechanism to compute our metrics consists of two parts; the process to estimate distances between nodes, and the process to compute the metric from the estimated distance.

The distance between nodes is estimated from the RSSI value observed with every hello messages of OLSR. That is, when a hello message is received, the metric of the directed link from the received node to the neighbor node is computed, and the metric value is updated. Note that RSSI decays in the inverse proportion to the square distance. Accordingly, we designed the formula to estimate the distance as follows:

$$L = \sqrt{\frac{a}{R}},$$

where L denotes the distance between two nodes, R does the RSSI measurement, and a does the decay coefficient. Note that a should be determined properly. The metric values are propagated via hello messages and topology advertisement messages (i.e., TC messages in case of OLSR) all over the network, and they are used in the shortest paths computation.

Our dynamic metrics are computed based on the estimated distance between nodes. As mentioned before, the metric function we use is a simple polynomial convex function. Let L_{max} be the maximum distance that allows communication between two nodes. M_{max} and M_{min} be the maximum and minimum metric values, respectively. Then, our metric function is expressed as follows:

$$M = (M_{max} - M_{min}) \times (\frac{L}{L_{max}})^n + M_{min}, \quad (1)$$

where n is a parameter to determine the curve of the function. Figure 4 shows the curve of the metric function for several

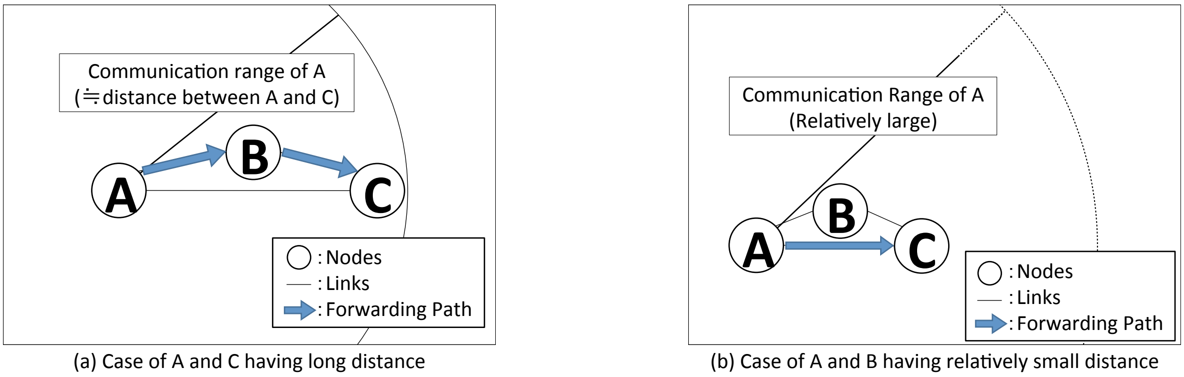


Figure 3: Desirable Paths with Node Distance

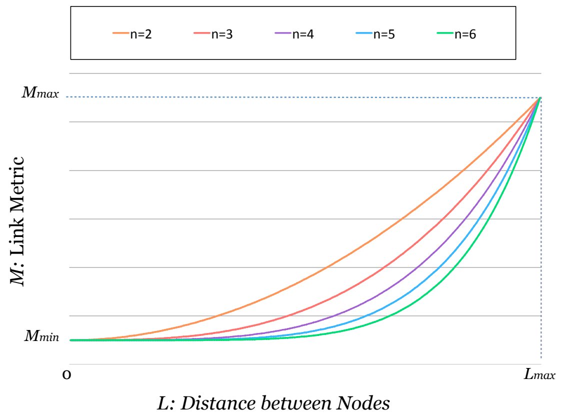


Figure 4: The Curve of the Proposed Metrics

value of n. The metric values take between M_{max} and M_{min} depending on the input distance that takes less than L_{max}.

3.3 Applying LMR

To reduce routing loops, we apply LMR to our RSSI based metrics described in Section 3.2. That is, by LMR, we limit the amount of metric change with a metric stretch r. Note that the amount of metric change in our RSSI based metric depends on the relative speed, the moving direction, and the distance between nodes. If the limitation of LMR on metric change is too strong, links are cut before their metrics have raised enough to use alternative paths. Conversely, if the limitation of LMR is too weak, routing loops appear that causes severe congestion. It is important to take the balance. We also note that dynamic metrics will not work when node speed is too fast. To find the node speed that our metric can catch up with is also important in the evaluation.

4 TRAFFIC SIMULATION

4.1 Scenario

We conducted a simulation using a network simulator Qualnet[13]. We implemented both our RSSI based routing metric and LMR by modifying OLSR module OLSRv2-NIIGATA, which is included in Qualnet version 5.0. We compared the performance of (i) the RSSI based metric and (ii) the RSSI based metric with LMR in the simulation.

We performed two simulation experiments. One is to investigate the relation between routing loops and link cuts, and another is to investigate the performance of our metric with various mobility parameters.

For the former simulation, we prepared 1000m$\times$1000m field to place 30 nodes in random location. Nodes move following Random Way Point model [12]. We tried two node speeds, i.e., 5km/h and 10km/h, and the pause time of nodes is 10 seconds. We generated 5 flows of 20kbps CBR (Constant Bit Rate) in 5 minutes, i.e., started at 1 minute and ended at 6 minutes from the beginning of the simulation. As the parameter that determine the curve of metric, we used $n = 4$. Note that OLSR have a mechanism called MPR to reduce control message load. To exclude the effect of MPR, we set TC_REDUNDANCY=2 so that all links are propagated into the network. As other OLSR parameters, we use default values. Note that when 1 minute past from the beginning of the simulation, all nodes share the information of all links.

For the latter simulation, we used the scenario similar to the former simulation. The difference is that we determined the default values for three parameters, and performed three simulations where one parameter varied while the other two parameter was fixed. The varied parameters were the number of nodes, node speed, and the parameter n in the metric function shown in equation (1). The default value of them were 30, 5km/h, and 4, respectively. In this simulation, we used our RSSI based metric without LMR because we intended to study the straightforward effect of mobility parameters against dynamic metrics. Also, the simulation time was 60 minutes.

4.2 Results: Routing Loops and Link Cuts

In Fig. 5, we show the packet reachability to the destinations with various values of r. Here, "power" means the case of RSSI metrics without LMR. In both 5km/h and 10km/h, the performance gets worse as the value of r goes lower. Totally the performance of lower mobility (5km/h) is better than higher mobility (10km/h).

In Fig. 6, we count the number of loop packets. We defined loop packets as the packets that reach the same node more

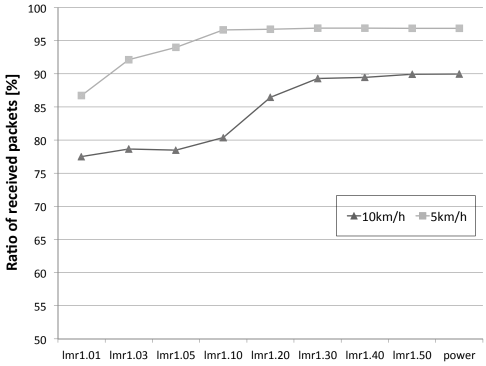


Figure 5: Packet reachability

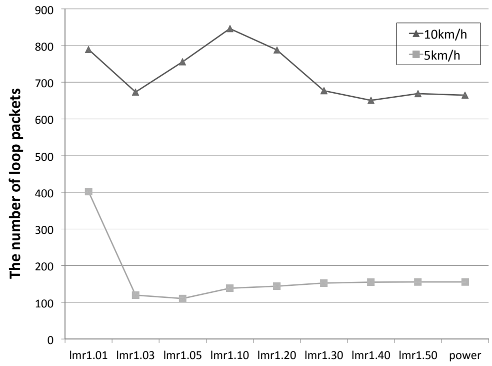


Figure 6: The number of loop packets

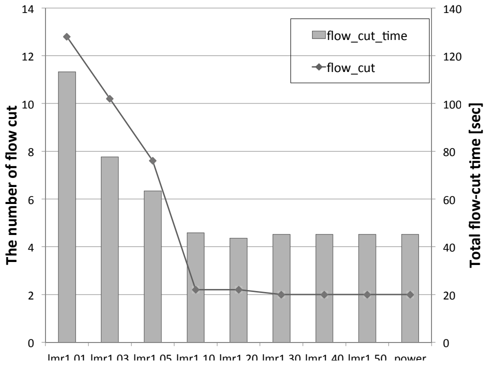


Figure 7: Flow cuts in 5km/h scenario

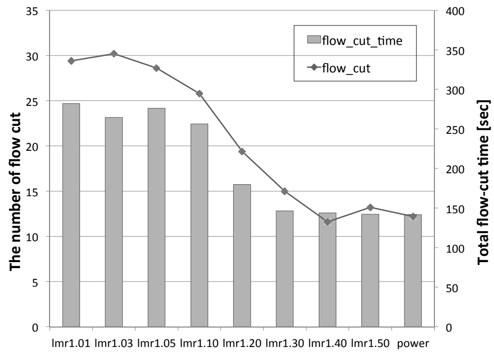


Figure 8: Flow cuts in 10km/h scenario

than once. First we found the number of loop packets is much larger in high mobility than low mobility. Note that there are many loop packets especially when $r = 1.01$ in lower mobility. This would be the effect of link cuts; when the limitation of LMR is too strong, links are cut before its metric is raised to the value enough to use alternative path. Consequently, if its new next-hop node is in the reverse direction of the destination, routing loops are created. Figure 6 shows this kind of loops, which caused of link cuts. Also, in the low mobility case, the number of loops gradually increases as r goes larger than 1.05. This implies that the effect of LMR to reduce loops appears when r gets lower. However, when r is lower than 1.03, the effect of link cut exceeds to this loop reduction effect. We conclude that the balance point is seen at $r = 1.05$ in lower mobility scenario.

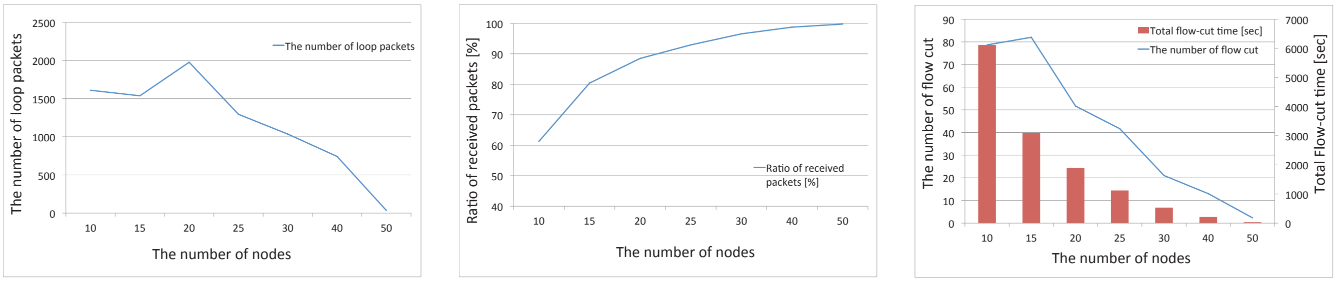
In contrast, such balance point is not seen in higher mobility scenario. This is because the bad effect of link cut is seen even in higher r, and simultaneously, the bad effect of loops is seen rather lower r. As a result, at the point around $r = 1.10$, the both effect is mixed so that their synergetic effects appear to be the highest loop counts. In fact, when we checked the event log of the simulation, the chain of those two factors, i.e., link cut cause loops then the loops cause another link cut and so on, are seen frequently.

In Fig. 7 and 8, we show the number of flow cuts and the total flow-cut time in both 5km/h and 10km/h scenario. We regard “flow cut” if CBR packets are not received in the period of more than 2 seconds at the destination node of each flow. The flow-cut time is the total sum of all link-cut duration of all of 5 CBR flows. Regardless of node speed, the performance goes worse when r goes smaller.

As we consider these four figures, we found several points to show. In Fig. 5, the difference of packet reachability between $r = 1.01$ and $r = 1.03$ in 5km/h scenario is about 5%, which is about 400 packets. In Fig. 6, the difference in loop packets is about 300 packets. It implies that 3/4 of the packet loss is caused by packet loops. In this part, the network performance deeply depends on packet loops.

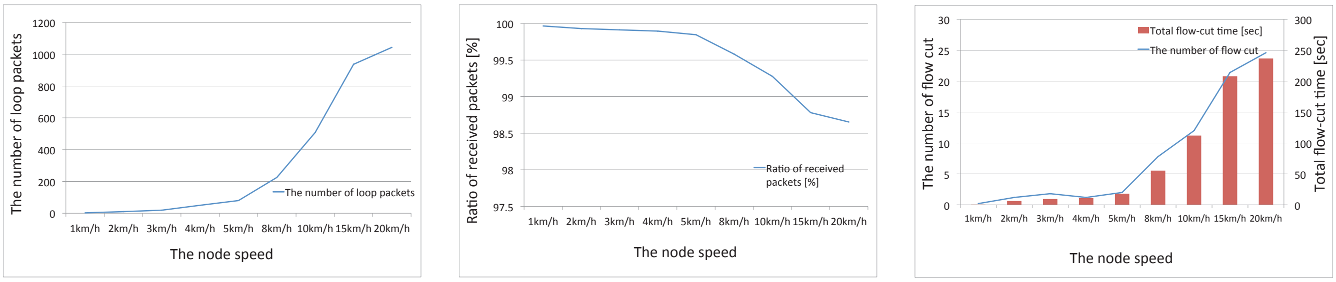
As another findings, see Fig. 6. we see the peak at $r = 1.10$ in 10km/h scenario. If we watch the right side slope of the peak and the packet reachability in Fig. 5 at the same r, we find that the packet reachability increases as loop reduces. This is also considered as the effect of loops. If we watch the left side slope, however, packet reachability does not change although loop packet reduces. This implies that packets are merely dropped instead of looping around $r = 1.05$. This is considered as the effect of link cut.

In summary, in this simulation experiment, we found that both of link cuts and routing loops effect on the performance of the network. Also, the relation between them is observed, i.e., link cuts create loop packets and vice-versa in the case of small value of r. We also found the balance point of those two in low mobility(5km/h) scenario, but in high mobility(10km/h) scenario we could not find the balance point because those two effects are mixed.



(a)Loop Packets (b) Packet Reachability (c) Flow Cuts

Figure 9: With Various Node Density



(a) Loop Packets (b) Packet Reachability (c) Flow Cuts

Figure 10: With Various Node Speed

4.3 Results: Effect of Scenario Parameters

To investigate the effect of scenario parameters on the performance of our dynamic metric, we show the results of three simulations. In Fig. 9 we show the results where the number of nodes (i.e., node density) varied. In Fig. 9(a), the peak of the number of loop packets appears at the node number of 20. When nodes become denser, loop packets decrease because the probability to find the next-hop node that is nearer the destination raises. If such next-hop nodes are always found, loops do not appear. In contrast, when nodes become thinner, loop packets decreases because the paths to the destination are easily lost. Therefore, in Fig. 9(b), packet reachability decreases as nodes goes thinner. Fig. 9(c) also shows this trend where the number and the time of flow cuts monotonically increases as nodes become thinner.

In Fig. 10 we show the results where node speed varied. These three figures show a simple trend that as node speed increases, the performance also decreases. Especially, note that the performance decreases rapidly when the node speed get faster than 5km/h. This means that our metric is possible to keep stability in the speed of walking. Note that, this is the result of default message interval of OLSR, i.e., hello interval is 2 seconds and TC interval is 5 seconds. If we use smaller interval, the proposed metric would work in higher mobility scenarios.

Finally, in Fig. 11, we show the results where the parameter n in the metric function varied. These three figures show that the performance is totally the same regardless of n.

5 CONCLUSIONS

In this paper we designed the a dynamic metric to solve the problem of communication (service) disruption caused by routing loops and link cuts due to mobility. Our metric is designed in combination with a RSSI based metric and a loop reduction method LMR to solve both of the factors.

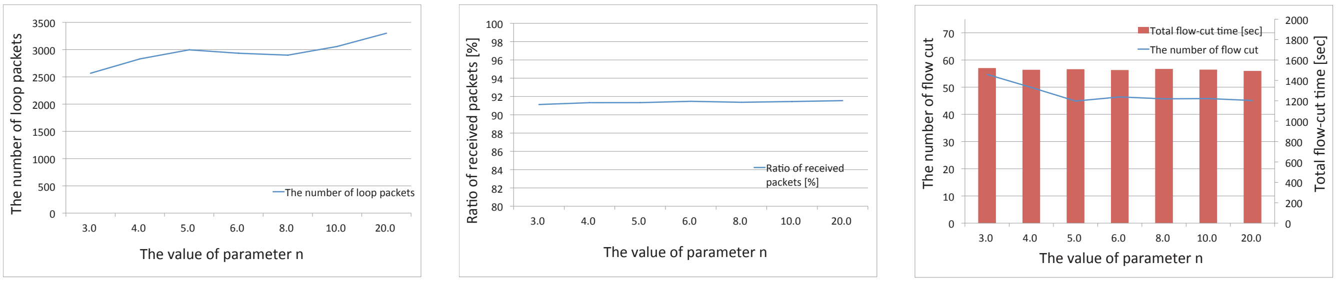
We conduct two simulation experiments to evaluate the performance of the proposed dynamic metrics in the scenario of which we exclude the effect of high traffic load. As a result, in 5km/h scenario, we found the balance point of the metric stretch r of LMR, which balances the two bad effects of routing loops and link cuts. Also, we found that the proposed dynamic metric can keep stable communication if the mobility is as fast as walking speed (i.e., 5km/h) and the node density is higher than a certain value.

Note that we can use reactive routing protocols such as AODV [2], which in general is regarded to be suitable for high mobility scenario. However, reactive routing protocols require re-construction of paths in case of link cuts so that users' communications are frequently disrupted. This study is an trial toward reliable communication in which users' communications are rarely disrupted using a proactive routing scheme.

As future work, we would like to develop the method to keep stability of the communication even in case of high-traffic-load scenarios.

ACKNOWLEDGMENT

This research is partly supported by Strategic Information and Communications R&D Promotion Programme (SCOPE), the Ministry of Internal Affairs and Communications, Japan.



(a) Loop Packets (b) Packet Reachability (c) Flow Cuts

Figure 11: With Various Parameter n

REFERENCES

[1] T. Clausen, and P. Jacquet, "Optimized Link State Routing Protocol (OLSR)," IETF RFC3626 (2003).

[2] C. Perkins, E. Belding-Royer, and S. Das, "Ad hoc On-Demand Distance Vector (AODV) Routing," IETF RFC3561 (2003).

[3] T. Yoshihiro, "LLD: Loop-free Link Stability Metrics for Proactive Link-State Routing in Wireless Ad Hoc Networks," Mobile Ad-Hoc Networks: Protocol Design, Xin Wang (Ed.), ISBN: 978-953-307-402-3, InTech (2011), Available from: http://www.intechopen.com/articles/show/title/lld-loop-free-link-stability-metrics-for-proactive-link-state-routing-in-wireless-ad-hoc-networks.

[4] T. Yoshihiro, "Reducing Routing Loops under Dynamic Metrics in Wireless Mesh Networks," IEEE Global Communication Conference, Exhibition, and Industry Forum (Globecom2010), pp.1-6 (2010).

[5] D. DeCouto, D. Aguayo, J. Bicket, and R. Morris, "A High-Throughput Path Metric for Multi-Hop Wireless Routing", Proceeding of ACM Annual International Conference on Mobile Computing and Networks (MOBICOM2003), pp.134-146 (2003).

[6] D. Draves, J. Padhye, and B. Zill, "Routing in Multi-Radio, Multi-Hop Wireless Mesh Networks," Proceedings of ACM Annual International Conference on Mobile Computing and Networks (MOBICOM2004), pp.114-128 (2004).

[7] Y. Yang, J. Wang, and R. Kravets, "Interference-aware Load Balancing for Multihop Wireless Networks," In Technical Report UIUCDCS-R-2005-2526, Department of Computer Science, University of Illinois (2005).

[8] C. Yawut, B. Paillassa, and R. Dhaou, "On Metrics for Mobility Oriented Self Adaptive Protocols," Proceedings of in Wireless and Mobile Communications 2007 (ICWMC2007) (2007).

[9] O. Tickoo, S. Raghunath, and S. Kalyanaraman, "Route Fragility: A Novel Metric for Route Selection in Mobile Ad Hoc Networks," Proceedings of IEEE ICON03, pp.537-542 (2003).

[10] A. Triviño-Cabrera, I. Nieves-Perez, E. Casilari, and F.J. Gonzalez-Canete, "Ad Hoc Routing Based on the Stability of Routes," Proceedings of the 4th ACM International Workshop on Mobility Management and Wireless Access, pp.100-103 (2006).

[11] Y. Shang, W. Ruml, Y. Zhang, and M.P.J. Fromherz, "Localization from mere connectivity," In Proc. ACM MobiHoc, pp.201-212, Annapolis, Maryland, USA (2003).

[12] J. Broch, D.A. Maltz, D.B. Johnson, Y-C. Hu, and J. Jetcheva, "A performance comparison of multi-hop wireless ad hoc network routing protocols," Proceedings of the Fourth Annual ACM/IEEE International Conference on Mobile Computing and Networking(Mobicom98), pp.85–97 (1998).

[13] Qualnet, http://www.scalable-networks.com/products/qualnet/ .

[14] L. Speakman, Y. Owada, and K. Mase, "Looping in OLSRv2 in Mobile Ad-hoc Networks, Loop Suppression and Loop Correction," IEICE Transactions on Communications, Vol.E92-B, No.4 (2009).

(Received March 19, 2012)
(Revised June 14, 2012)

Katsuya Fuji received his B.E. degree from Wakayama University in 2011. He is currently a master course student in Wakayama University.

Takuya Yoshihiro received his B.E., M.I., and Ph.D. degree from Kyoto University in 1998, 2000 and 2003, respectively. He was an Assistant Professor in Wakayama University in 2003-2009, and from 2009 he is an Associate Professor in Wakayama University. He is interested in computer networks, graph theory, bioinformatics, medical systems, and so on. He is a member of IEEE, IEICE and IPSJ.

Submission Guidance

About IJIS

International Journal of Informatics Society (ISSN 1883-4566) is published in one volume of three issues a year. One should be a member of Informatics Society for the submission of the article at least. A submission article is reviewed at least two reviewer. The online version of the journal is available at the following site: http://www.infsoc.org.

Aims and Scope of Informatics Society

The evolution of informatics heralds a new information society. It provides more convenience to our life. Informatics and technologies have been integrated by various fields. For example, mathematics, linguistics, logics, engineering, and new fields will join it. Especially, we are continuing to maintain an awareness of informatics and communication convergence. Informatics Society is the organization that tries to develop informatics and technologies with this convergence. International Journal of Informatics Society (IJIS) is the journal of Informatics Society.

Areas of interest include, but are not limited to:

Computer supported cooperative work and groupware
Intelligent transport system
Distributed Computing
Multi-media communication
Information systems
Mobile computing
Ubiquitous computing

Instruction to Authors

For detailed instructions please refer to the Authors Corner on our Web site, http://www.infsoc.org/.

Submission of manuscripts: There is no limitation of page count as full papers, each of which will be subject to a full review process. An electronic, PDF-based submission of papers is mandatory. Download and use the LaTeX2e or Microsoft Word sample IJIS formats.

http://www.infsoc.org/IJIS-Format.pdf

LaTeX2e

LaTeX2e files (ZIP) http://www.infsoc.org/template_IJIS.zip

Microsoft Word™

Sample document http://www.infsoc.org/sample_IJIS.doc

Please send the PDF file of your paper to secretariat@infsoc.org with the following information:

Title, Author: Name (Affiliation), Name (Affiliation), Corresponding Author. Address, Tel, Fax, E-mail:

Copyright

For all copying, reprint, or republication permission, write to: Copyrights and Permissions Department, Informatics Society, secretariat@infsoc.org.

Publisher

Address: Informatics Laboratory, 3-41 Tsujimachi, Kitaku, Nagoya 462-0032, Japan
E-mail: secretariat@infsoc.org

CONTENTS