Eco-System Design Based on Internet Architecture Framework

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Abstract

Future Internet will contribute to the improvement of efficiency regarding all the activities developed and deployed on the Earth. The internet system discussed in the paper is not only meant the global computer network using the IP (Internet Protocol), but is rather logical architecture of the system applied in the Internet architecture. As discussed in Green ICT business, we need the ubiquitous and global scaled sensor and actuator networks in order to develop and to deploy the energy aware system. In this paper, the author discusses why the "Internet" is very efficient platform, leading to Eco-System. Many networks to contribute to energy saving and to environment preservation as a control-plane, will adapt the IP technology, so as to deliver the Eco-City or Eco-Town. The design principle is (1) Avoiding the fragmentation of IP systems and networks, (2) Encourage the collaboration among sub-systems, that use IP or may not use IP, (3) Explore the Eco-system, that delivers the cheaper system development and deployment, while preserving the technical and business innovations.

Key words: *Internet, Eco-System, Green IT, sensor network.*

1. Introduction

Future Internet will have to contribute the improvement of efficiency regarding all the activity developed and deployed on the Earth, i.e., saying smarter city or town. The internet system discussed in the paper is not the global computer network using the IP (Internet Protocol), but is rather logical architecture of the system applied in the Internet. As discussed in Green ICT business, we need the ubiquitous and global scaled sensor and actuator networks in order to develop and to deploy the energy aware system. In this paper, the author discusses why the "Internet" is very efficient platform, leading to Eco-System. Many networks to contribute to energy saving and to environment preservation, will adapt the IP technology. However, these networks would be of so-called closed IP network, which is not connected to the global Internet.

For many under-discussing/under-developing "future" networks, even when it would be a closed network, it will be a global network. However, these may be disconnected, i.e., fragmented. So as to conduct and to deliver the innovation, the network should be interconnected with smaller technical and operational difficulties. Also, it has been proven by the existing Internet that building the network by single entity is so/too expensive, but shared by multiple entities may be far cheaper for all entities.

ISOC (Internet Society; www.isoc.org/) Board of Trustee (BoT) has a concrete direction regarding the future Internet, which is toward the Internet Eco-System. Eco-system has the sustainability, while preserving the continuous innovations. It may not optimal solution, but, as a result, it is flexible and adaptable, against the change of condition or environment with low cost.

As a background, when we look at large computer systems, including facility networks, there are many systems and networks that adapt the IP (Internet Protocol). However, still, there are many non-IP or closed IP systems, in the real world. And, many networks and systems tend to be fragmented, from the view point of each company's business strategy. This is serious concerning toward the "Eco-System" development.

This paper tries to define the objective and goal of the future Internet for smarter city or town. It is that; (1) Avoiding the fragmentation of IP systems and networks., (2) Encourage the collaboration among sub-systems, that use IP or may not use IP, (3) Explore the Eco-system, that delivers the cheaper system development and deployment, while preserving the technical and business innovations.

2. Future Internet

2.1. What is an Eco-System?

An Eco-System is a natural unit consisting of all plants, animals and micro-organisms in an area functioning together with all of the physical factors of the environment. Ecosystems can be permanent or temporary, in both spatial domain and in time domain. An Eco-System is a unit of interdependent organisms which share the same habitat. Eco-Systems usually form a number of food webs/chains, as the interaction among the independent organisms.

In the area of economics, the Eco-System is defined as a business structure among related organizations (e.g., private companies), which form the cooperative and collaborative business activities to yield benefits and innovations for themselves.

With the author's understanding, the followings are some of required features for Eco-Systems;

(1) **Independency** of individuals and sub-systems
Each individual and sub-system must live or be operate-able by themselves, at least temporally.

(2) **Autonomous** operation of individuals and sub-systems
Each individual and sub-system can make their operational and governance rules by themselves.

(3) **Interaction** among individuals and sub-systems
Individual and sub-system have some level of interaction, e.g., cooperation and collaboration, with other individuals and sub-systems.

(4) **Adaptability** against the change of environment
Individual and sub-system can adapt themselves, according to the change of environment.

The existing Internet and the future Internet, discussed in the following subsection, have the features of Eco-System described above. Also, the framework of Internet architecture could be applied to the other systems, such as energy system, educational system or e-healthcare system.

2.2. How the Future Internet Looks Like

The professional Internet system has been operated more than 20 years, while preserving the continuous introduction of technical innovations. There are many discussions on "future Internet" or "post Internet architecture".

The Internet architecture does not mean the particular protocol suites, such as existing TCP/IP. TCP/IP itself has experienced a lot of protocol modifications and functional enhancements, during the deployment of global Internet system. We must recognize that the Internet architecture is the "logical" architecture framework, not the particular protocol sets nor routers and switches [1]. The Internet architecture, of course including the future Internet, must preserve the following five essential features of the Internet architecture. These are (1) autonomous, (2) distributed, (3) disconnected, (4) inter-domain, and (5) global, operation. The current Internet system has been challenged by the following three aspects; global, ubiquitous and mobility.

According to the experience of development and deployment of the Internet system and Internet architecture, the use of live testbeds has been very effective to realize the requirements of the system and the future direction of research and development. We may realized the importance of "Experienced Design"[2] and of "Invention is the mother of necessity"[3], by the Internet development history. The TCP/IP suite has been modified and has been added new functions, according to the real operational experiences. Without the real operational experiences at the testbeds, we could not recognize and find the technical innovation or evolution. This would be a implementation of "Eco-System" in the computer networks or information and communication networks.

2.3. Change of Technical Assumptions

As known as Moor's law, the IT technologies have been achieved the exponential performance improvement for more than three or four decades. According to the continuous improvement of ICT technologies, the technical and system assumption for system design has been significantly changed. The followings are the old and legacy system and technological assumptions, which would be long time considered as the given condition.

1. User and end-station is poor and stupid
2. Users' terminal only turns on, when it is needed
3. Fixed node is far major and superior than mobile node
4. "service" must be provided either by provider or by enterprise
5. Cost of transmission, storage and copy, is not little, but is expensive

Especially, the assumption 5 would be recently realized a wrong assumption, by the introduction of Peer-to-Peer (P2P) technologies over the transparent IP network. It has been believed that Internet architecture must be transparent, sometimes said as "stupid network", as the default system architecture, when we design the large scale computer networks.

The other important paradigm shift from the current R&D tendency regarding the Internet architecture is regarding the assumption on the communication model if the nodes are always connected or not. We have developed and deployed the broadband internet environment, especially in the developed countries. However, even in the metropolitan area in the developed countries, we have experienced the case of disconnection from the network. In the under-developing counties or in the country side of developed counties, we have many geographical areas, which does not have any connectivity to the Internet.

2.4. Requirements for Future Internet

The followings are the requirements for the future Internet system, from the view point where how the future Internet looks like.

(1) Covering our “Earth” with high speed network, i.e., global scale Eco-System
According to the significant installation of land-cables and submarine-cables in the last decade, the fiber-cable system has been surrounding the surface of our Earth, including the under-developing countries, as a backbone network of the Earth.

(2) Design and obtain the “earth” scale computer system
We could obtain the enough network resource and computing resource, which are distributed on the Earth and are somehow connected by digital networks. Here, this computer system is a collection of sub-systems, which can operate independently, while the sub-systems are somehow interacting to each other, i.e., as a aspect of interaction and independency for Eco-System.

(3) Impossible to accommodate earth with single technology
We have wide variety of technologies so as to connect the digital devices. In order to maintain the continuous innovation of networking technology, we have to intentionally maintain the capability of alternativeness in the networking components. This feature, i.e., diversity and replace-ability, leads to the aspect of sustainability and adaptability in Eco-System.

(4) Investment and operation is always autonomous
Installation and operation of system by the single organization is neither scalable nor realistic. We have to design the system, which collaborates and cooperates to each other in a distributed and autonomous manner.

(5) We have large area, where we could not be wired
The legacy Internet system (or computer system) would assume that the nodes are interconnected via the stable wired cables. However, in the current and future computer networks, the larger number of nodes is connected to the network via the various wireless links.

(6) We have large area where, even, wireless would be hard to use
Though we have a lot of nodes, which are connected to the network via wireless links, we will still have a lot of nodes and area, which could not be connected to the Internet. This will be true both in country sides and even in metropolitan sides.

(7) Uni-Directional Digital Link
The legacy Internet system would assume that the nodes are interconnected via the bi-directional links. However, the current and future Internet will use a lot of uni-directional (digital) links.

(8) Real integration between “logistics”
Small size of mobile nodes, such as sensor or actuator nodes, will be connected to the Internet, and those nodes would be attached with the wide variety of objects. A typical object would be of the logistics, which are likely to the new object and a contribution of the future Internet system. This could be said as the integration of current cyber space with the logistics or as the “real-space” internet.

2.5. Key Components for Future Internet

The followings are some key components for the future Internet system.

(1) DTN [4]
DTN represents Delay Tolerant Networking or Delay Disruption Networking. The legacy Internet architecture has implicitly assumed that the communicating peers can mutually transact the IP packets with a certain and reasonable latency. However, in order to accommodate all the digital equipments and human-being on our planet, we could not assume that all the equipments and human-being were always connected to the Internet.

(2) Message routing [5][6]
The existing Internet system has adopted the (IP) packet routing. In the IP packet routing, the source node resolves and informs the destination IP address with TCP/UDP port, before the source node starts the communication, i.e., source node initiates the communication. However, in the future Internet system, (a) the source nodes may want to send the data, without resolving and informing the particular destination node(s), and (b) the peer nodes may not be required any state synchronization for data communication. The message routing, e.g., publisher-subscriber model, would be a possible communication model in the future Internet system.

(3) P2P technology
P2P technological framework would be a key component of future Internet system. We could implicate the P2P technology as followed, i.e., introduction of three key functions into the existing “naïve” Internet architecture;
1. {networked} Cache and Proxy
2. {networked} DMA (Direct Memory Access)
3. {networked} Virtual memory system (by DHT)

2.6. Deployment of Future Internet Infrastructure

In this subsection, the author discusses how the future Internet infrastructure should be developed and deployed.

(1) "Experienced Design" [2]
None of us living with the current Internet system may know how the future Internet will be. The future Internet system will be the result of interaction with real society, i.e., technologies will be modified and mutated via the practical feed-back from the real operation. In order to adjust with the practical, un-expected and un-forecast-able feed-backs, the initial future Internet system should have technical vagueness and room to be able to be added or to be modified, in the future, as the architecture design principle.

(2) "Invention is the mother of necessity" [3]
None of us may know how to use new technologies. Also, the new technologies would introduce the new functions or services with their native interfaces. The emulating the legacy or existing services with new technologies may not good for the development of new technologies. New technologies may eager their "native" applications or services.

(3) Challenging to the theme of physics, economics and mathematics
The networking and digital technologies have been always challenging the legacy themes. It will be time-domain, geographical-domain or economical-domain.

(4) Federated networking for the next stage of the "Internet".
Though many networks will adapt the IP technology, these networks would be of so-called closed IP network, which is not connected to the global Internet. For many under-discussing/under-developing "future" networks, even when it would be a closed network, it will be a global network. However, these networks may be disconnected, i.e., fragmented. So as to conduct and to deliver the innovations, the networks should be able to be interconnected with smaller technical and operational difficulties. Also, it has been proven by the existing Internet that building the network by single entity is so/too expensive, but shared by multiple entities may be far cheaper for all entities; "Eco-System", that is the aspect of cheaper system cost. As a result, we should avoid the fragmentation of individual (global) IP networks, as a governance of digital network development and deployment.

3. Energy Saving Business "BY" ICT

3.1. Potential of Business Opportunity "by" ICT

Energy saving and the protection of environment for sustainable society is now global agenda, which we must achieve for the next generation and for our Earth. This activity around IT and ICT industry is called as "Green IT/ICT". Though the most of the Green IT/ICT would focus on the energy saving "of" IT/ICT equipments, we are focusing on the energy saving "by" IT/ICT technologies.

It is said that the revenue contribution by ICT industry in the GDP is less than 10%. More than 90% revenue is come from non-ICT industries. Nowadays, almost all the companies depend on ICT technology for their corporate operation. And, how to use the ICT defines the marketing power and operating power of companies.

One of new business area for ICT industry would be energy saving using the ICT, such as Internet technology.

Figure 1 gives the energy consumption in Japan, as of 2005. One third is by manufacturing, one third is by energy generation and transportation, and last one third is by daily life by us. Also it shows that offices and residents consume more than 20% of energy. We are spending a lot of money on utility or energy.

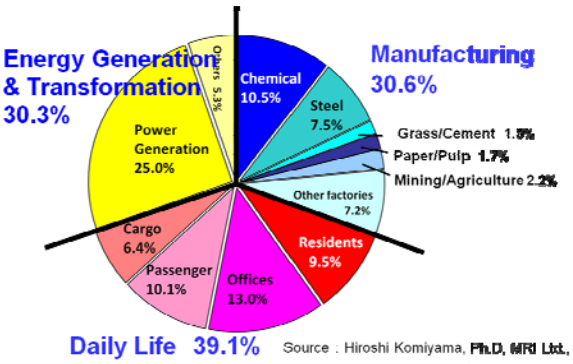

Figure1 Japanese Energy Consumption in 2005

And, the facility system, such as building system, uses a lot of proprietary technologies by each segment and by each company. For example, it has been reported that the major complex in down-town Tokyo has more than 200 K monitors and actuators in a single building, while each sub-systems would use different technologies.

So, we can realize that the energy saving is now "Global" agenda, as well as good new business area for ICT industry. This is because all the facility components must be monitored and controlled by computer system, so as to achieve the effective energy saving performance. However, the facility system uses a lot of proprietary

technologies and components have never cooperated to each other, in the past.

People in facility networking area start to realize the benefit of open system, such as Internet technology and Internet architecture. We have two important messages delivered at last INTEROP Tokyo, held in June 2009.

(1) The concept of "smarter planet" offered by IBM, saying to let smarter all the facility and activities by computer networks or by ICT. We will have computer networks, which will be able to achieve global scale real-time PDCA cycle.
(2) The fact that a lot of energy consumption is by facility system, rather than ICT equipments. For facility system, more than 75% of energy is consumed by non-ICT equipments, such as HVAC (i.e., air conditioning system) or by lights.

Some data shows that, surprisingly, the initial construction cost and the lifetime utility cost is almost the same amount. This is a big business potential and incentive for each organization.

3.2. Third Wave of City/Metropolitan Design Principle

We would be the process of innovation or revolution, regarding how to design to build the city or metropolis.

(1) The first wave; agricultural age
At this age, the agriculture is the main industry, and the symbol of valuable assets would be fruitful and fertile land, mainly a farmland. Rich people in the age have larger rich farmland. Therefore, the village or city was built near the river and the location, where have good weather. In other words, the most important parameter or component would be a water supplying infrastructure.
(2) The second wave; industrial age
At this age, the manufacturing is the main industry, and the symbol of valuable assets would be artificial products, objects or money. Rich people may love to have much products or money. Therefore, the city or metropolis was built at the location, where the logistics condition is better. In other words, the most important parameter or component to build the city would be a logistic infrastructure.
(3) The third wave; information age
At this age, the digital intellectual activity would be the main industry, and the symbol of valuable assets would be knowledge or intellectual property, with less energy consumption. The best performance on intellectual activity is recognized as the responsibility of civilized people or country, and is recognized as the global agenda. Rich people may love to have rich intellectual communication and life. Therefore, the city or metropolis was built so as to effective network environment, with effective energy supply and demand system. In other words, the most important parameters or components to build the city or town would be an information infrastructure and energy SCM(Supply Chain Management) infrastructure.

3.3. Contribution of Internet and Internet Architecture Framework

The future Internet system, that is a real object of the Internet, will be a nerves system, and the server systems, such as cloud computing platform, will be a brain, in the future smart city or smart town, when we compare the smart city/town with the human-being. Even when human has strong components, e.g., leg, arm, muscle or bone, the human can not work well without coordinated control among the components. When we have better coordination and cooperation among the components (organs), we can achieve the same work with less energy, or we can achieve better work with the same energy consumption. This means that, so as to achieve an Eco-body in human body, the nerves system and brain must achieve high performance to integrate all the information at components, and to control the components. On the contrary, the components have to run somehow independently and autonomously. Of course, each component has diversity and replace-ability, for the sustainability of human body and it's component. As a result, the future Internet system will contribute to the Eco-Social-Infrastructure development through the physical entity and though the concept of Internet architecture framework, discussed in section 2.

When we observe the future computer facility in a city or in a town, a lot of computers, currently in every organization, will move into IDC (Internet Data Center), at least by the following two reasons. Computers widely spread in cities or in towns can communicate with far smaller latency and larger bandwidth, since the physical distance among the computers can be reduced. Also, the computers can be installed stable and better environment, regarding the temperature control and power supply management. The other benefit will be the achievement of energy saving as a total system. When we run the computers in the individual offices, we must run the air-conditioning system 24 hours a day, so as to take care the heat generated by the computers. However, when we move these computers to IDC, we will be able to reduce the amount of energy consumption at the {usual} offices. Energy consumption will move to IDC, since IDC can have far better operational efficiency than the {usual} office. Based on the above discussion, we are designing the system and protocol architecture of future Internet system, especially focusing on the facility networking. The referenced architecture is shown in figure 2. It is the

database-centric architecture. We allow various types of field-bus technologies, while those filed-bus systems report to the data to {global scale} shared database. Any application on the Earth can access any data in shared database using the same API. Also, the control and management API between the field-bus system and applications are commonly defined.

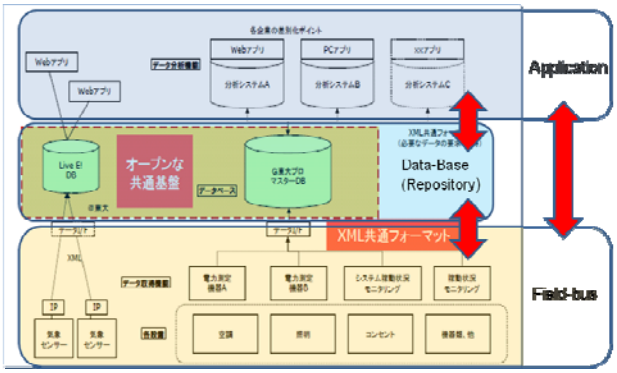

Figure2 Referenced Architecture for Facility Networks

3.4. Eco-System Development Scenario

The real target of energy saving by ICT is not the energy saving itself, but is to establish ubiquitous digital sensor and actuator network environment and to encourage the technical innovation/revolution or new applications using this network platform.

We try to establish the Win-Win relationship between environment /energy-saving and ubiquitous networking.

As the Step 1, we have to establish the following three mandatory components;

1. Sensors and actuators network
2. Collaborative operation among individual components
3. Control the energy flow using the information.

Then, as the Step 2, we will obtain the ubiquitous digital space sharing all the digital information. Here, the important point is each equipments and components are already paid-off for their own objectives. Finally, we would go into Step3; using this ubiquitous digital space, we could deliver a lot of inventions, innovations and new applications using the same infrastructure.

We could realize that this is a yet another “end-to-end” model that the Internet has achieved. So, the real goal of energy saving activities using ICT (and by future Internet system) is sharing any digital information over the globe, so to achieve higher efficiency on human and social activities and to establish the digital network infrastructure to achieve sustainable innovations.

4. Conclusion

In this paper, first, the requirements, key components technologies and the methodology of system development / deployment for the future Internet, which must preserve the continuous introduction of technical innovations, are discussed. The Internet architecture must preserve the following five essential features; (1) autonomous, (2) distributed, (3) disconnected, (4) inter-domain, and (5) global, operation. Though many networks will adapt the IP technology, these networks would be of so-called closed IP network, which is not connected to the global Internet. We have to avoid that these networks will be disconnected, i.e., fragmentation. So as to conduct and to deliver the innovation, the network should be interacted with smaller technical and operational difficulties. Also, it has been proven by the existing Internet that building the network by single entity is so/too expensive, but shared by multiple entities may be far cheaper for all entities.

Then, this paper discusses the contribution of ICT system and of the future Internet for energy saving, that is now global agenda for all the countries and for human-being. We should design the energy saving system, similar as the “Eco-System”, as the existing Internet system has achieved. By the achievement of sharing any digital information over the globe, we will be able to deliver higher efficiency on human and social activities and to establish the digital network infrastructure to achieve sustainable human and social innovations.

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