Impact of NGN Architecture by Intelligent Terminals

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Abstract:
This paper discusses the impacts on the existing NGN network architecture by the intelligent terminals or NGN terminals. An economical and simple network with multitudes of services can be realized if terminal intelligence is utilized for functions traditionally performed by the network. The existing terminals without required intelligence can also be supported via terminal emulation at the edge of the network. Communication is established between the interested parties by the combined efforts of the NGN terminals and the network. A possible network architecture where the NGN terminals and NGN network co-operation is suggested. The benefits for such network, such as increased network robustness, interoperability and scalability, are explored in this paper.

1 Introduction

Many discussions regarding the NGN architecture have been carried out in recent years, such as the contributions to ITU-T NGN FG, ITU-T SG-13/Q3, 3GPP/3GPP2, and Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN). As a result of contributions from many individuals and network experts, two very similar NGN architectures emerged without fundamental differences. One is recommended by ITU-T[1] and the other is introduced by TISPAN[2] under the leadership of the European Standards Organization.

The NGN architecture is designed to support all types of terminals, with the most unintelligent terminal being used as the base-line terminals to be supported. In this case, the network is performing all the required tasks to establish communication sessions without any terminal involvement.

While the legacy terminals are being phased out, the current NGN architectural framework cannot utilize the terminal intelligence to simplify the network architecture, to improve the network performance, and to achieve certain Capital Expenditures (CAPEX) and Operational Expenditures (OPEX) savings.

While all types of user terminals are to be supported inside a network, the way those terminals are to be supported will make a huge difference in the network architectural design. It can be dumb terminal centric design, as discussed in [1] and [2], or it can be intelligent terminal centric design, as discussed in the following sections.

In this paper, it is proposed that the network design uses the intelligent terminal (called NGN terminal) as the base-line terminal. Other types of terminals are supported via NGN terminal emulation at the edge of the network. The network and terminals or terminal emulators will cooperate to establish multimedia communication sessions between the communicating entities, which may or may not be human.

Using this design philosophy, the user may not perceive any difference in satisfying his or her communication needs. But the functions provided at the core of the network will be different between the dumb terminal centric approach and the NGN terminal centric approach. The differences range from the way normal value-added services are provided to the way a new type of service can be introduced. Because of differences in basic network functions, the network architecture could be different. This paper studies the impact of NGN network architecture by using the NGN terminal centric approach.

The high-level functions of NGN terminal can be summarized as following:

- Basic Call Processing

The session establishment for the multimedia communication will be the responsibility of the terminals. In this case, the terminal is responsible for session establishment, maintenance, and tear-down. If there is connectivity in the transport stratum, the terminal only needs to know the routable address of the called party or its service agent (e.g. IP address) to establish such communication.

- Charging Information Collecting

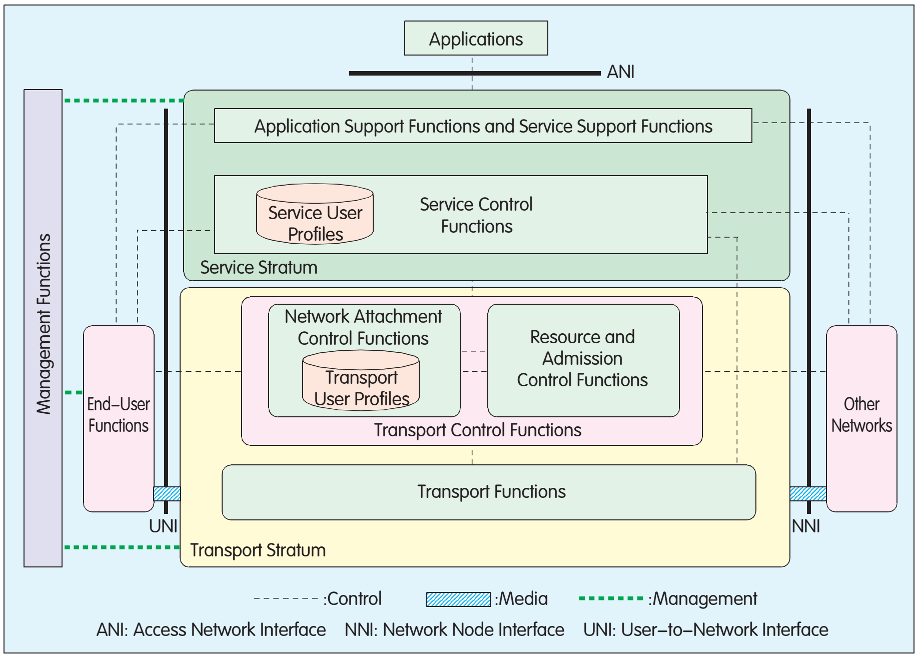
The NGN terminal will also be responsible for collecting charging information (e.g. start and end time and duration of a particular session, packet transferred/received, involved parties, etc.), so that the network can collect information for billing purposes. Security measures are to be implemented to ensure the correctness of the information.

- Basic Services

The NGN terminal is also responsible for certain traditional value-added services such as call blocking and call forwarding. Those services can be implemented on the terminals with easy user interface and user customization capabilities.

There are other characteristics of NGN terminal in the area of security, registration, and authentication which will not be further elaborated.

With the network and the NGN terminal to accomplish the work which was performed inside the network alone, the current standardized network



▲Figure 1. General NGN architecture in Year 2012.

architecture needs to be modified. Some functions which are exclusively inside the network (e.g. directory lookup for the called parties) will be exposed to the NGN terminals while others functions can be completely eliminated from the network (e.g. session establishment). As will be shown in the paper, such re-arrangement of the network functions will make the network more robust, scalable, and interoperable.

This paper will be structured as follows: Section 2 will explore, using examples, what could be done with the intelligent NGN terminals; Section 3 will further investigate the impact of the network architecture by the NGN terminals; Section 4 will outline a few common open issues; and concluding remarks will follow in Section 5.

2 Network with NGN Terminals

An NGN consists of the transport stratum and the service stratum. The NGN architecture outlined in [1] is shown in Figure 1 for easy reference.

The transport stratum consists of transport functions and transport control functions. The NGN terminal has no impact on the transport functions. The transport control functions can be further divided into the resources and admission control functions and the network attachment control function. In general, there is no major impact on those architectural components partitioning while their functions will be different.

The major architectural impact on the current NGN architecture by intelligent NGN terminals lies in the area of service stratum, which is the focus of this paper. Before the details are investigated, a few examples are used to highlight the potential differences when terminal intelligence are utilized.

2.1 Session Setup

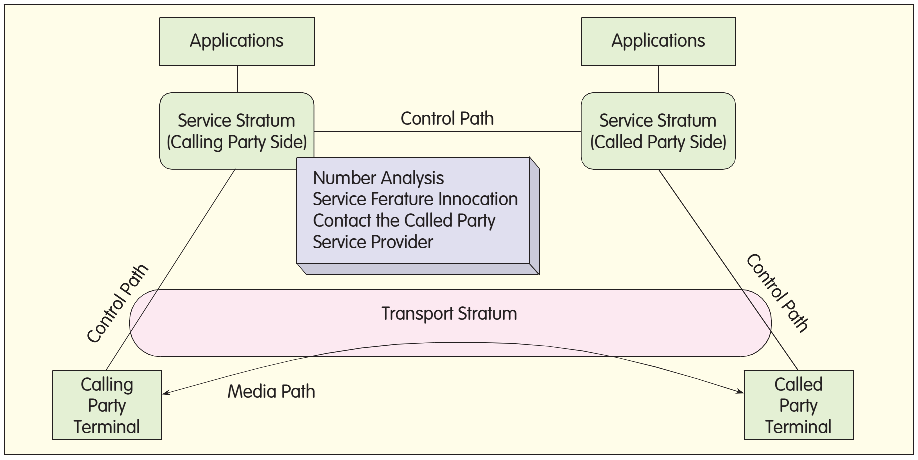
One of the key functions of the network is to set up a session between two communicating terminals. In this section, the session setup process will be used to illustrate the potential differences when the terminal intelligence is actively used.

In the traditional network, the user terminals intelligence, if there is any, are not utilized. In this case, the network is tasked to perform many functions. A simple session setup task by the traditional network can be illustrated as in Figure 2.

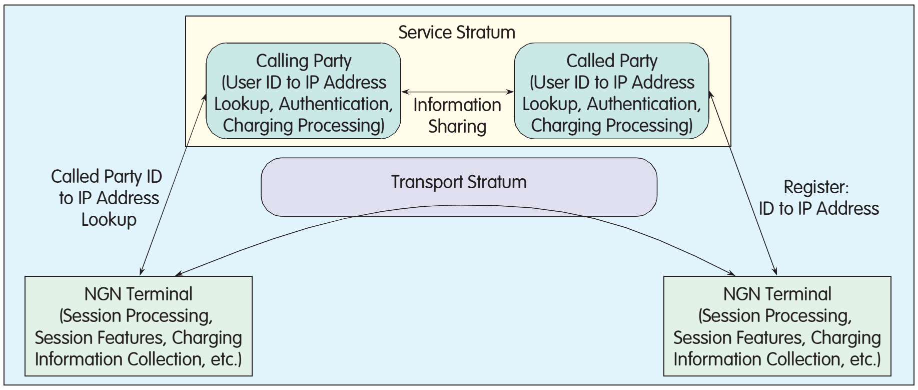
In this setup, all the complexity of session setup will be the responsibility of the network equipment. While this type of configuration is needed for terminals whose intelligence can not be used, it leads to complicated network architecture, as evidenced in [1]. Besides, the network will also need to keep the session state while the session is active, which introduces robust and scalability issues.

Conceptually, if the calling party knows the called party's current routable address in the packet network based transport stratum (e.g. IP address for an IP based transport stratum), a session can be set up between those two terminals using terminal intelligence alone.

However, getting the other party's current routable address (e.g. IP address) will be almost impossible given the dynamic nature of the address assignment. Hence a translation mechanism is needed to associate the user identifier, which identifies the user and is human-friendly, with the current routable address of the user terminal. How the user is identified and how the user identifier is assigned



▲Figure 2. Session setup based on current NGN architecture.



▲Figure 3. Session setup in NGN with intelligent terminals.

has been flagged as an open issue in Section 4 and will not be further pursued in this paper. But each user is assumed to have a unique identifier in the NGN environment in order to be identified, and such identifier is not the routable address in the transport stratum.

In the intelligent NGN terminal case, the session setup could be illustrated as in Figure 3.

In the above diagram, the core functions of the service stratum are outlined, which include the following aspects:

- Directory Lookup

For any given user ID, an IP address is provided if the user can be located, other session-setup-related information can also be included.

- Authentication

During the terminal registration phase, the user terminal needs to be authenticated for security considerations.

- Charging Processing

While the charging information is collected by the terminals, the processing of the charging information is the responsibility of the network.

- QoS or Resource Control

While the intelligent terminals can negotiate with the network, the actual control of QoS or network transport resource is the responsibility of the network. The control could be segment by segment, or end to end.

The NGN terminal, which is assumed to be intelligent, will be responsible for session setup, maintenance, and tear-down. Traditional Value-Added Service (VAS) features, such as session blocking and session forwarding, can be implemented on the intelligent terminal solely.

Other traditional VASs, such as caller ID blocking, can be realized by service agent or relay equipment inside the network which behaves like a back-to-back user agent. The network may also provide default IP address for terminals which is off-line for session forwarding purposes.

It should be noted that, using terminal intelligence, the service stratum could eliminate the needs to maintain the session state information, which improves the network scalability, network robustness, and network performance.

It should also be noted that, the boundary of the service stratum is not restricted in the boundary of the transport stratum. In open pervasively connected transport stratums, the service stratum could reach the far end of the interconnected transport networks.

2.2 Applications

With intelligent terminals, the means to provide applications can also be different from the current NGN architecture. As evidenced in Figure 1, the application is provided via Access Network Interface (ANI) with service and application supporting functions in the service stratum.

One implication of such architecture is the applications provided by IP Multimedia Subsystem (IMS), which is outlined in Figure 4.

In this setup, the application server is invoked by the Serving Call Session Control Function (S-CSCF) based on information provided by the user in the session setup message and the Home Subscriber Server (HSS). In this case, for introducing any new services, at least the data in HSS needs to be modified to take account of the new service information and its subscription.

This type of setup is required if the intelligence of the terminals are not to be used. In this case, very basic features, such as conference session and session blocking, are to be implemented by the network. On the other hand, it is almost impossible to provide vast array of services the current Internet is providing.

By using terminal intelligence to handle basic session features, the environment to provide applications can be shown as in Figure 5, which is very close to the mechanisms of providing services over the Internet.

While the application and service supporting functions, shown in Figure 1, still exist in the service stratum, the functionality of them is very different. In this case, the network is essentially providing a directory lookup, associating services provided by a particular service entity with its current IP address.

When the user intends to invoke the service, the mechanism used will be the same as that of session setup discussed before. The only exception is instead of using a user ID to identify the user; the operator of the intelligent terminal will use

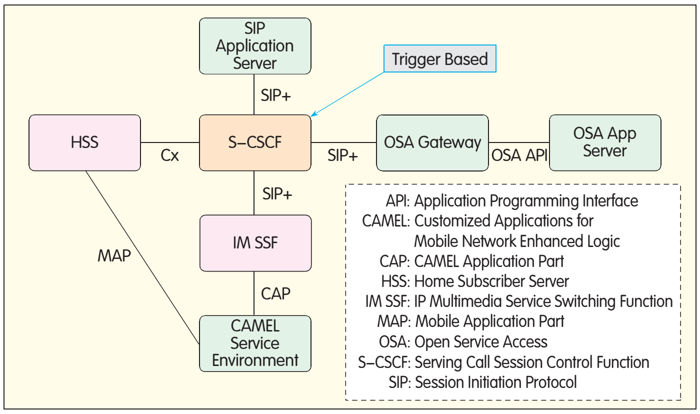
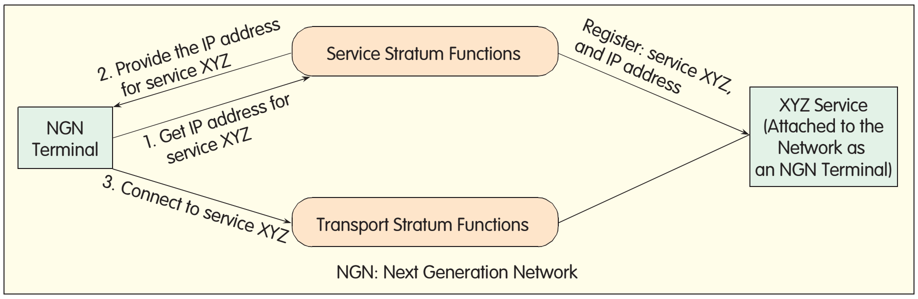


Figure 4.▶ IMS application environment: application of NGN architecture.



▲Figure 5. Application environment for NGN terminals.

a service ID to invoke a particular service. In this case, introducing a new service will be similar to introducing a new user in the network.

The user centric service model not only provides more flexibility of service selection and end–user experience, but also decreases the burden of service stratum and potentially increases the scalability of the network and robust of the network.

2.3 Carrier Equipment Implications

In the traditional network, the reliability requirements for all the equipment in transport stratum and service stratum are 99.999%. This stringent requirement ultimately increases the cost of the equipment and results in the added cost for the consumers.

The root cause of this requirement is due to the fact that, without using terminal intelligence, there is a single point of connectivity between the terminal and the service stratum, as shown in Figure 6.

By using terminal intelligence, multiple control connections can be established from the NGN terminal to different service stratum equipment. In this case, there is no need for service stratum equipment to be 99.999% reliable. In this case, the network is providing the required reliability while individual equipment does not have to be super–reliable. The relaxing of such requirement will reduce CAPEX for the carriers and increased reliability for the users.

3 Network Architecture using Terminal Intelligence

As shown in Section 2, some traditional networking functions will be migrated into the terminals if the terminal intelligence can be utilized.

There are many aspects of network where terminal intelligence can be used; the functions migrated from the network to the NGN terminals can be summarized as follows:

(1) Session Related Management

This area includes session initiation, session maintenance, and session termination.

(2) Session Related Features

This area is traditionally called Value–Added Services (VASs), which includes call forwarding, call blocking, call waiting, three–way call, etc.

(3) Charging Information Collection

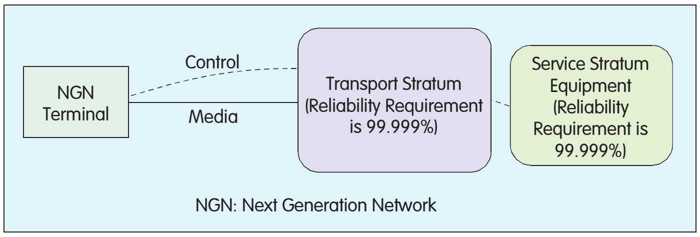
The terminals will also be responsible for charging information collection. Processing the information will be the responsibility of the services providers, which will depend on factors outside the scope of architecture discussion. A security mechanism needs to be implemented so that the accounting information can be reliably transferred to the network for further processing.

With those functions migrated into the terminals, the service stratum of the NGN network will focus on efficient directory lookup, subscriber authentication, account information processing, and others.

3.1 High Level Architecture

From the high level, the architecture of the NGN network using terminal intelligence will be very similar to that shown in Figure 1, which is depicted in Figure 7.

Figure 6.▶ Single connection between terminal and service strata in the traditional network.



The differences of Figure 1 and Figure 7 are in the designation of the end–user functions. In Figure 1, the end–user functions do not imply the existence of applications while, when terminal intelligence is considered, most applications will be treated as a new user terminal, as discussed before.

Instead of generic applications in Figure 1, only the push type application will be using, proactively, the service stratum and transport stratum in order to push content to the subscribers from the service provider. One example of such push application would be advertisement, which allows flexible business model in terms of subscriber subscription plans.

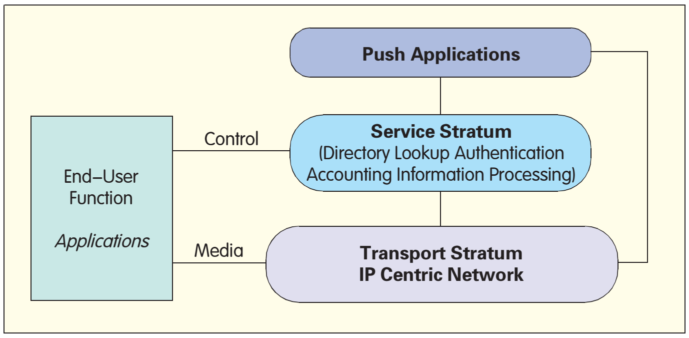
3.2 Detailed Architecture using Terminal Intelligence

In the detailed NGN architecture based on Year 2012, the potential terminal intelligence is not utilized for possible architecture simplification on network side. As eluded in the previous sessions, the key function of the network, in establishing connectivity between the parties concerned, are directory lookup, authentication, and charging information processing. With this in mind, the NGN architecture utilizing the potential terminal intelligence can be illustrated as in Figure 8.

The key points of this architecture can be articulated as follows:

- NGN Terminal Emulation

In order to provide legacy terminal support (terminals which intelligence can neither be utilized nor exist), the NGN terminal emulation is used in the network. With more and more NGN terminals introduced, intelligence of which can be used by the network, the NGN terminal emulation can be phased out. This is in strong contrast with the existing architecture where the legacy terminals are supported across various architecture components, which is difficult to phase out the legacy support.



▲Figure 7. High level network architecture using terminal intelligence.

• Directory Lookup

The directory lookup service is exposed to the terminals and will serve the terminals directly. Furthermore, the directory lookup service is also communicating with other provider's directory lookup service for called parties information if not available locally. It should also be noted that managed VPN services can also be achieved via proper manipulation and management of the directory lookup function.

• Charging Information Processing

In this architecture, it is the joint responsibility of NGN terminal and the network to perform the accounting functions. The NGN terminal will be responsible for recording the details of every activity of the subscriber while the network will provide an accounting statement based on the information provided by the NGN terminal. Obviously, security is one of the major concerns in this area. Because the NGN terminal is always connected to the network, and various audits can be used to ensure the integrity of the accounting information. By moving the accounting information collection to the terminals, there is no need to keep the "session state" inside the network for accounting purposes. This will significantly increase the scalability of the network.

• Authentication

The proposed architecture will reuse a modified version of Network Attachment Control Function (NACF)[3] or Network Attachment Subsystem (NASS)[4], with modifications to support mobility and different means of access mechanisms.

• Resource Management

The resource control part will be a modified version of Resource and Admission Control Function (RACF)[5] or Resource and Admission Control Subsystem (RACS)[6] to cover both the mobile and fixed network environment. The RACF will also need to consider the network neutrality legislation in various countries, such as EU and USA.

• Push Applications

The primary usage of push application should be to insert network sanctioned messages into the media stream (e.g. advertisement). This is achieved with the joint effort of the application itself and the packet access devices (e.g. DSLAM).

• Gateways for Interworking

The interworking with the existing network part takes the traditional gateway approach. The functionalities of those gateways can be well defined and, with the standardization of the network architecture, those other types of network will be phased out.

With the proposed network architecture presented at the high level and at the somewhat detailed level, the benefits of such architecture needs to be articulated, which is given in the next section.

3.3 Benefit of the Proposed Architecture

By utilizing the terminal intelligence, the benefits to the network can be summarized as follows:

(1) Complexity in Architecture

Compare with the NGN architecture based on Y.2012 and Figure 8, the simplification in terms of network architecture is obvious. By reducing the complexity of the network architecture, the following aspects of the network can be improved:

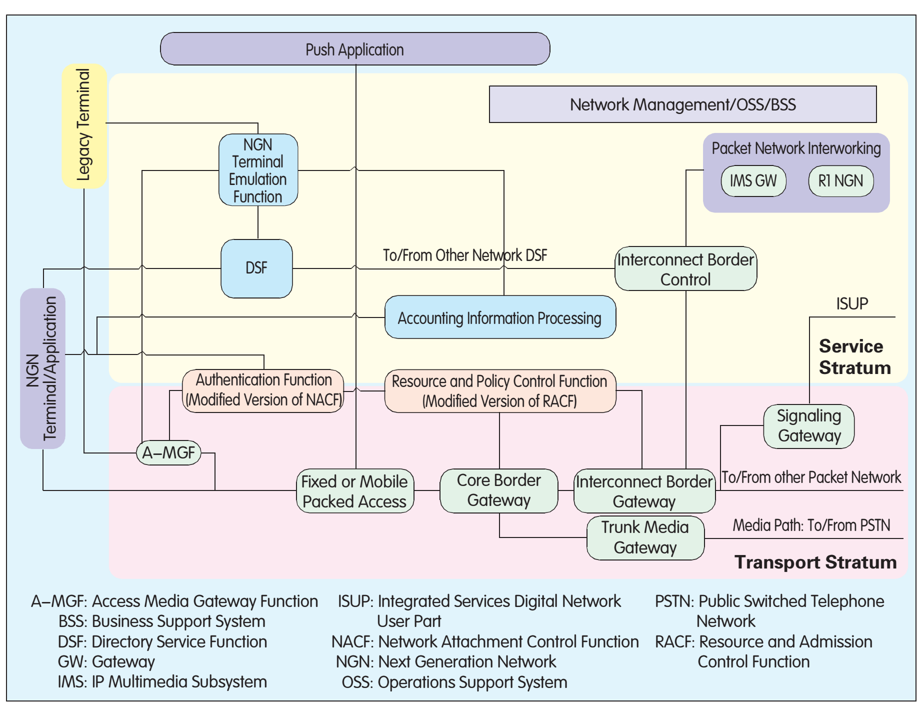
• Robustness: The network can be more robust due to the reduced network complexity.

• Interoperability: With less reference points to worry about, the interoperability of the network is definitely improved with the proposed network architecture.

• Scalability: With the transferring of network complexity to the users, the scalability of the network is definitely improved because there is almost no state information in the network.

(2) Reduction in CAPEX

With the proposed NGN architecture,



▲Figure 8. NGN architecture using possible terminal intelligence.

the CAPEX can be reduced in the following areas.

• With the exception of the NGN terminal emulation function, the equipment hosting other architectural components may not necessary to have the 99.999% reliability in the service stratum due to the fact that NGN terminals can have control connectivity with multiple instances of those architectural components. Hence the reliability of the network is achieved due to multiple instances of the architectural components, instead of a supper reliable component. This will translate to equipment savings in terms of hardware, development savings in terms of both hardware and software. This will also increase the robustness of the network, as stated before that "simplified architecture result in robust network".

• Since the user terminal is part of the network, the carrier's CAPEX savings could be realized from the user terminal purchasing. In another words, the users are contributing to building the network, instead of the service providers alone. Of course, this realization of savings will also subject to carrier's business model.

• Since the network has much less session related states to maintain, the equipment will be simpler and hence translated into the CAPEX savings.

(3) Reduction in OPEX

The operational cost of the network operation can be reduced due to:

• Flexible in Service Introduction

With the proposed architecture, introducing a new service (with exception of push type services) is similar to adding a user. This will enable many providers for the same service and enable many different types of services. As eluded in the previous paragraphs, the introduction of new services, in the current NGN architecture, requires at least some types of data fill to incorporate the service into the network. In the proposed architecture, a new services, especially a new types of service, can be introduced by connecting the service, as a terminal, to the network and advertise the service, in the same way of advertising a user.

• Equipment Maintenance and Monitoring

With exception of NGN terminal emulation, the NGN network under the proposed architecture will be simple to maintain because it only focuses on a few functions with possibility of non-fault tolerant hardware (e.g. one maintenance item need for fault tolerant hardware is to ensure the fault detection and switching over function are functional. Such exercises were one of the major contributions of equipment outage in practice.)

• Upgrade

Because the resilience is network based instead of nodal based, the nodal software and hardware upgrade will be much easier and much less error prone, which will be translated into the OPEX savings.

4 Open Issues

For the NGN networks, there are a number of open issues to be resolved, which may not be exclusive to the proposed architecture:

(1) User Identity

A user needs to be identified by its permanent identity, not its current routable identities, such as IP address or the E.164 number without number portability. Furthermore, the user needs to be identified across language and country boundaries. The user identity assignment and management needs to be resolved before the NGN network could be widely utilized.

(2) Regulatory

Regulatory issue could also hinder the acceptance of the NGN network. In the proposed network architecture, the service stratum and the transport stratum may not belong to the same carrier. The current VoIP provider is also utilizing this fact on small scale.

(3) Directory Distribution

This is more or less related to the user identity issue. Technically, a mechanism needs to be established to distribute the association between the user identity and its current routable address (e.g. IP address). Distributed database algorithms may be used for such purposes, similar to the distributed database lookup in the various P2P networks. This is also the area in need of standardization.

(4) Standardization

On using the terminal intelligence, a standard based interface between the terminals and the network needs to be established. Since the network and the terminals are cooperating to establish communication sessions, a clear definition of such interface is essential.

5 Conclusions

This paper presents the possible impact of the network architecture where terminal intelligence was utilized. If the terminal intelligence is used, the network complexity can be reduced, which increases the robustness, interoperability, and scalability of the network.

By using the terminal intelligence, the CAPEX of the network can be reduced due to employing simpler network architecture, using network-based reliability, and sharing the network functions between the network and terminals. Besides, the OPEX of the network can also be reduced due to flexible service introduction, less maintenance work, and easy upgrade mechanisms.

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Biography

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Li Mo holds a PhD degree from Department of Electrical Engineering of Queen's University. He is CTO of ZTE USA (a wholly owned subsidiary of ZTE Corporation) and is a member of the Global Marketing Team for ZTE. Dr. Mo has over 20 years of experience in the telecommunication industry, including extensive work in Fujitsu, Nortel and IBM, prior to his joining ZTE in 2001. His current research interests include P2P network, IMS, and Fixed Mobile Convergence (FMC). Dr. Mo is an active member of IEEE, ETSI, and ITU, where he is an editor for five recommendations, and is an associate rapporteur of Q1/SG13.