Paper

Survey of NGN migration profiles deployed by selected carriers in Europe, North America and Asia

Wojciech Michalski

Abstract— The paper presents the alternative migration profiles to next generation carrier network architecture. It describes the paths of development of fixed public network infrastructure for five selected service providers. The carriers are selected as being in advanced stage of migration towards NGN. Moreover, examples of varying strategies ranging from full PSTN replacement and NGN overlay to constructing an NGN network from the ground up as well as examples of various migration strategies, especially based on IMS and softswitch solutions are presented.

Keywords— NGN, IMS, softswitch based solution, NGN migration strategies, network evolution.

1. Introduction

This article presents profiles of selected carriers as examples of alternative network migration strategies. It describes technical status of carriers's networks when the migration process began, the transformation process and its consequences.

Strategies were selected mainly from the point of view of carrier's goals and influence of factors like cost of maintaining the public switched telephone network (PSTN), competition and development of voice over IP (VoIP) and multimedia services market.

While each operator develops its own unique network migration path, carrier strategies can be categorized into three main groups: full PSTN replacement, new generation network (NGN) overlay and NGN construction step by step from the beginning. Replacement depends on the removal of time division multiplexing (TDM) switches and access infrastructure. It enables seamless transition of plain old telephone services (POTS) users to IP call/session control. Overlay enables migration of subscribers to IP-based, multimedia environment. It includes continued support of existing infrastructure. Carrier's migration paths include some combinations of particular options, especially partial PSTN replacement with NGN overlay. Combination ensures swiftest transformation, but requires significant capital expenditure (capex).

The carriers presented below were selected as examples of above mentioned migration strategies. For purposes of this analysis five carriers were chosen: British Telecom, Slovak Telekom, FastWeb, China Telecom and Verizon, representing three continents: Europe, Asia and North America. By analyzing development of carrier NGN migration strategies it is possible to answer to the question – when will the mass migration to VoIP occur?

2. PSTN replacement – a BT strategy

This strategy is deploying by one of the greatest European carrier – British Telecom (BT). BT is the incumbent telephone service provider in United Kingdom (UK). In June 2004, carrier advertised their converged network migration plan, called the 21st Century Network (21CN). According to the plan, BT declared to build an NGN network over the next six years. The plan assumes replacement of core PSTN network with an IP network based on the IP multimedia system telecoms & Internet converged services & protocol for advanced networks (IMS TISPAN) architecture.

British Telecom began an NGN trial in 2004. First, end-to-end communication was set up between three major network nodes, one located in Cambridge and two in London. In the first phase, 1000 subscribers participated in trials of end-to-end voice and data services over Internet protocol multiprotocol label switching (IP/MPLS) network. In the second step, by June 2005, BT added additional 3000 subscribers to the pilot network.

Now, to support future broadband growth, BT creates an IP/MPLS core network along with the consolidation of central offices and deployment of multiservice access nodes (MSANs). This process will continue during 2009, when nearly all BT subscribers will be served through NGN access nodes. The MSANs nodes will be handling POTS subscribers too, but no special provisioning of equipment at the customer promises or central office is required.

Large scale migration of non-PSTN services to the NGN began in 2007. BT plans that over 50% its current POTS users will have migrated to the 21st Century Network by 2008.

To support NGN broadband services, BT adopted a service creation platform that consists of components such as authentication, directory and profiles, quality of service (QoS) and presence/location. These components can be combined in a modular fashion when new services are created.

2.1. Next step

In the business market, BT implements the migration plan to the next generation services now. But to retain enter-

prise customers, BT must continue to expend its enterprise NGN infrastructure, so BT will build an overlay network to specifically address the enterprise market.

Operator knows that further profits could be limited by marriage of wireless fidelity (Wi-Fi) and cellular network and by making BT a "transport only" carrier. To defend his position, BT needs to be a major market player providing NGN customer services. To defend his status, it also needs a wireless networks, although there is a large number of cellular competitors in the UK.

2.2. Usefulness of this method

For BT, the total cost of maintaining the PSTN is higher than for other European incumbents, because it possesses an extensive network infrastructure and must fund all maintenance and upgrades on many switches. For this reason, BT chose the strategy of PSTN replacement.

Many big and small incumbents in other countries also prefer the strategy of full PSTN replacement. PSTN replacement has been initiated by many carriers in Asia, Australia and Oceania. Telecom New Zealand has elaborated an aggressive plan to migrate to NGN architecture over the next few years. Similar plan is advertised even in the small country of Brunei. Forward thinking companies have even outsourced network maintenance and management of both its wired and wireless networks.

3. Partial PSTN replacement and overlay – a Slovak Telekom migration strategy

Strategy of partial PSTN replacement and overlay has been chosen by Slovak Telekom (ST), the incumbent telephone service provider in the Slovak Republic.

In the early 1990s, the telecommunication infrastructure in the Slovak Republic was in very bad technical state. But in a few next years, ST has upgraded portions of the network with fiber cable, synchronous digital hierarchy (SDH) transport systems and digital circuit switches. By 2000, ST has digitized over 70% of the PSTN infrastructure.

Modernization process of ST network didn't cover rural networks still served by electromechanical switches. In this situation, delivering services with required QoS parameters was a big problem. ST reported nearly 28 faults per 100 main access lines in 2000.

As a majority owner, Deutsche Telekom initiated actions to fully digitize the ST network by the end of 2004. Under the contract signed in April 2004, Alcatel was obliged to supply next generation infrastructure to replace analog switches and transmission equipment. According to the contract, Alcatel replaced over 300 small analog switches handling over 200 000 subscriber lines with single Alcatel 5020 softswitch ($1+1$ configuration) and over 7500 Media Gateways operating together with other PSTN switches.

At the transmission level, the core network was built using an IP/MPLS technology. The country was divided into three regions: west, central and east and each of them was configured with dual Cisco GS 1200 core routers for network survivability.

Like most incumbent carriers in Eastern Europe, ST has a foreign ownership which plays important role in the migration process. Thanks to this, ST has greater access to investment capital, technical knowledge and operations expertise.

3.1. NGN technologies a chance for countries lacking advanced infrastructure

Development of NGN infrastructure in the Slovak Telekom network is an excellent example of success on the world scale. This example shows us what several incumbent carriers did over a few years. At first glance, the idea that rural areas having low population densities, low computer and Internet penetration as well as low demand for telecommunication services are to be equipped with NGN infrastructure seems illogical. According to popular opinion, primarily a low cost network solutions should be installed in rural areas. Thanks to jump to NGN, Slovak Telekom can minimize network investment, increase number of subscribers in next years and attain important social goals, such as upgrading rural telecommunication services.

Network transformation process will probably last many years, and ST will establish overlay broadband access networks (digital subscriber line (DSL) and wireless) with connectivity to the IP/MPLS core network over this time. ST will deliver VoIP services to drive further PSTN migration.

3.2. Usefulness of this approach

Strategy based on co-existence on NGN and PSTN infrastructure will be common around the world. If a growth of VoIP and other NGN services will be slow enough, the cost of this process shall remain acceptable.

The least developed countries (LDCs) in Africa and Southeast Asia have infrastructures like Slovak Telekom before the upgrades. Therefore, LDCs will likely emulate the ST network migration strategy. They will leapfrog the digital circuit switch technology and replace electromechanical exchanges in rural areas with NGN-IP infrastructure.

4. NGN overlay – a China Telecom strategy

China Telecom is a true monopoly telecommunication carrier serving two thirds of China territory and controlling the national long distance network and provincial networks in 20 provinces, autonomous regions and municipalities.

For European people, it is hard to imagine to growth of China Telecom fixed network over the past decade.

In 1998, China Telecom had 87.4 million total main access lines. By the end of 2003, number of subscribers increased to 263 millions, and by the end 2004 to 299 millions. In 2008, there will be an estimated over 310 million main access lines. China Telecom also has over 40 million wireless users and over 12.5 million DSL broadband subscribers. Although broadband deployment has been growing at the rate of over 200% per year, China Telecom represents only 11% of total residential access lines.

4.1. China Telecom network evolution

The national backbone network of China Telecom is based on fiber-optic cable systems linking provincial capitals. During the 1990s, the transmission network based on fiber cables was upgraded with SDH transport systems, forming rings for improved survivability.

China Telecom PSTN consists of five-level circuit-switched network and all major national transit exchanges are duplicated. The national and provincial PSTNs are relatively new, with age ranging from 10 to 15 years. Age of telecommunication network in China is not a primary factor influencing the necessity of upgrades. The network development is caused by economic growth and increasing subscriber demand. These factors have decisive influence on growth of traffic volume in the network. For this reason, China Telecom started to deploy a next generation overlay network.

Carrier began this processs in October 2004 when it has selected Lucent and Nortel to upgrade its existing SDH national backbone network. Under the contracts, Nortel upgraded existing metropolitan optical networks with wavelength division multiplexing (WDM) in ten major cities and Lucent installed its WaveStar OLS 1.6T high-capacity dense wavelength division multiplexing (DWDM). These contracts show that China Telecom wants to retain the existing TDM-based PSTN network for many years yet.

In November 2004, China Telecom has advertised the award of major contracts for the construction of IP/MPLS core network that are part of the ChinaNet Next Carrying Network (CN2), designed to support IP-based consumer and business services.

In 2002, China Telecom has started softswitch trials with multiple equipment vendors. These trials included Alcatel's, Nortel's, Ericsson's and Lucent's equipment and each of them was dedicated to test system performance, network interworking and equipment inter-operability. Moreover, the goal of the trials was to provide China Telecom with expertise in supporting business VoIP multimedia services.

In July 2003, Shanghai Telecom, a China Telecom's subsidiary, has concluded a contract with Alcatel for construction of next generation metropolitan network. Under this contract, a network was deployed based on Alcatel softswitch, media gateway and litespan multi service access gateway equipment to support integrated IP voice, data and multimedia services over asymmetrical digital subscriber line (ADSL) and Ethernet broadband connections.

4.2. Overlay networks in China Telecom in the past

Overlay networks have been used in China Telecom over the past 25 years. First, digital exchanges and integrated services digital network (ISDN) overlay networks were deployed to upgrade communication services to government and business customers. Than, gradually, the SDH transport systems and fiber-optic cable systems were installed to support the PSTN digitalization.

Overlay networks in China Telecom have been deployed for reasons that remain unchanged to this day. First, the size of China Telecom network causes that deployment of new technologies occurs in phases. Moreover, when this type of deployment is adopted, investment is finished after each phase. Third, under any scenario, replacing about 200 million digital switch lines would take a long time.

Unlike BT, which prefers a next generation network solution that supports the new as well as old services, China Telecom will not adopt old services in its network. Interworking in the existing PSTN network is based on new requirements, but old services, such as narrow-band POTS need not be supported by the next generation network platform.

4.3. Usefulness of this method

Overlay networks permit rapid implementation of new services in selected geographic areas and minimize the risk of disruption to existing PSTN network. This is why China Telecom selected such a strategy, because similarly to operators in other emerging countries, it must meet the immediate demand from businesses for IP-based services.

Establishing overlay networks gives many advantages, but the concept of overlay network has one fundamental disadvantage: no reduction of network cost, because maintaining the existing PSTN infrastructure and building IP/MPLS overlay network is necessary.

5. Construction of NGN step by step from the beginning – a FastWeb strategy

In 1999, FastWeb was established as a joint venture between AEM, Milan's utility and e.Biscom. The company is an Italian broadband telecommunications service provider. Using AEM's underground ducts, FastWeb has built an extensive fiber optic cable network covering Italy's major metropolitan areas.

FastWeb provides dedicated Internet access, voice and video-on-demand (VoD) services, offered to business and residential customers. Thanks to its fiber network, the company was the first European carrier to offer 10 Mbit/s Ethernet-based Internet access to customers (it also uses DSL to provide service beyond its own network coverage).

5.1. Development of FastWeb's network infrastructure

Transformation process was initiated in backbone network, where FastWeb built its fiber-optic transmission network. The core transport network consists of SDH STM-16 dual-fiber, bi-directional ring, supplied by Alcatel. In each core network node, the Cisco 12000 series IP routers are installed. At the customer premises, Cisco's Catalyst switches are used for access and traffic aggregation purposes.
Modernization process of FastWeb network was divided into 5 phases. In phase 1, H.323 as well as access gateways to support VoIP services (translation of E.164 to IP address) were implemented. Call control to each of the access gateway devices as well a supporting endpoint registration is provided through dedicated gatekeepers and the access to the PSTN through the italtel multi service solution (iMSS) softswitch platform.
In phase 2, the softswitch-based service-layer application platform was implemented. This platform has made the provisioning of voice services more efficient and has improved call completion by dynamically rerouting calls upon congestion. In 2002, NetCentrex CCS softswitches were introduced to manage call routing and signaling as well as to offer full set of voice services. FastWeb installs one CCS softswitch cluster for each zone covering about 200,000 users (each CCS cluster provides N+1 redundancy). Moreover, in this phase, a video application platform was added, to support broadcast television, video conferencing and VoD services over its fiber-to-the-home (FTTH) network.
In phase 3, FastWeb deployed session initialization protocol (SIP)-based gateways in its network. Earlier, in phase 2, an Italian access gateway supplier Telsey had deployed its H.323 access gateways. Subsequently, NetCentrex and Telsey worked together to develop a SIP-based access. At the same time, FastWeb installed MSANs, to support the provision of broadcast television services over its ADSL network.
In phase 4, NGN services including server-based applications such as presence and multimedia business services were implemented.
In phase 5, connectivity with other IP networks and application domains were added. FastWeb network evolution composed of 5 phases is not finished yet, because FastWeb still continues to expand network capacity.

5.2. FastWeb network as a VoIP oriented architecture

During FastWeb's network evolution a trial with services expansion was made. In each step of this process consumer and business product as well as services portfolio was added. Thanks to a fiber-optic backbone network, FastWeb has distinguished itself from Telecom Italia and other competitors with high-bandwidth data services. From the beginning, FastWeb has made voice communications a major part of its business model and has recognized that VoIP services will be a fundamental sector of services market to ensure profitability.

5.3. Usefulness of this method

Many other competitive local exchange carriers (CLECs) around the world prefer network migration strategies similar to FastWeb's, because the role and scope of VoIP services will increase in future and NGN architecture will give the carriers the most competitive standing on the voice services market.

6. PSTN replacement – a Verizon strategy

Verizon, being one of the greatest of US carriers, deploys a PSTN replacement without expansion of territorial coverage. Verizon was created in 2000 after a merger of Bell Atlantic and GTE Corporation. Thanks to the merger, Verizon combined the Bell Atlantic operating region with ILEC telephone operations throughout the US midwest, southeast and west. Currently, Verizon operates in 30 states and has also international operations in Puerto Rico and Dominican Republic as well as Vodafone OmniTel in Italy. Moreover, Verizon and Vodafone own Verizon Wireless – the largest wireless carrier in the US.

6.1. Development of Verizon's network infrastructure

Verizon began replacing its long distance national transit (class 3) circuit switches with packet switching technology in 1999. During 2004, the softswitches were installed for class 4 inter-city transit applications. The replacement of primary toll switches and upgrade of the national transit network to IP technology took place in 2003.
In 2003, Verizon established an IP/MPLS backbone network which operates IP over SONET based on Lucent solutions. Under the contract, Lucent supplied SONET equipment for metropolitan network applications and LambaXtreme ultra-long-haul DWDM optical equipment installed in the national backbone network.
In 2004, the company it began deploying fiber-to-the-premise (FTTP) access network in selected states with data speeds of 622 Mbits downstream and 155 Mbits upstream. Moreover, in 2004, under the contract with Nortel, Verizon also began replacing GTD-5 EAX local exchanges.
Verizon deploys FTTP on a regional basis, with complete replacement of copper PSTN access network. Its strategy is a full PSTN replacement rather than establishing a PSTN overlay.

6.2. Usefulness of this method

Public switched telephone network replacement gives Verizon advantages similar like in the BT case. Similar to British Telecom, Verizon found the high PSTN maintenance costs as significant factor in replacing portions of the access network. Moreover, like BT, Verizon will continue support for PSTN circuit switches for many years in the future. For this purpose, Nortel has received contract

for the softswitch support and Lucent has received similar contract for 5ESS product support.

Other carriers in Canada and US will probably also adopt similar migration strategies. TELUS covering British Columbia in Canada is expanding its services with a fiber based IP backbone network. Bell Canada is expanding its coverage to provide service across Canada and the US. The combined SBC and AT&T will also deploy its network in similar manner, adopting an in region PSTN replacement and out of region expansion strategy.

7. Conclusion

Examples presented in this article illustrate trends in migration of traditional network to NGN. Now, many carriers in the world build or upgrade their networks to meet requirements imposed by new broadband multimedia and VoIP services.

In Europe, this process was first initiated by BT, which elaborated and introduced network transformation strategy based on IMS system. BT has adopted a full PSTN replacement strategy and had an immediate need to develop an IP/MPLS core network to support both enterprise and consumer services. Currently, BT consolidates its central offices and deploys MSANs to lower operating costs.

Similar strategies, but based on softswitch solution are deployed by other carriers in Europe, e.g., by FastWeb in Italy an by Slovak Telekom in the Slovak Republic. ST has implemented an interesting network transformation scenario promising to go from electromechanical exchanges to NGN infrastructure without the necessity of deploying digital exchanges, employing a hybrid network migration strategy. In future, rather than deploying existing digital circuit switches, it will deploy an NGN architecture with centralized softswitch control and distributed media gateways, based on redundant IP/MPLS core network. FastWeb, being an Italian CLEC, has built an NGN network from the ground up. It was primarily a fiber based bypass service provider, providing broadband services (up to 10 Gbits) to businesses and customers in 14 metropolitan areas. Its network control layer and application servers were introduced via a softswitch deployment.

Carriers in other countries, e.g., France and Germany concentrate mainly on the works concerning planning and elaborating of network transformation strategy suitable to technical characteristics of existing infrastructure and economic standing of the carriers.

In Asia, advanced works concerning transformation of traditional network to NGN infrastructures are carried out by operators in South Korea, China and Taiwan, which, like in Europe, are deploying various scenarios based on IMS and softswitch solution as well as various options of this strategy (PSTN replacement, overlay). China Telecom is an excellent example of a carrier with a network overlay migration strategy. Having PSTN infrastructure about ten years old, China Telecom is constructing an NGN to support the introduction of IP based enterprise services and to expand network capacity for entry into the 3G mobile market.

In North America, Verizon has adopted a migration path based on PSTN replacement in the region and out of the region expansion. It operates with IP as well as circuit-switches services, providing unified messaging, call management and other PC-based applications. It has established a national IP/MPLS backbone network and has introduced web-based, overlay services for managing home and business communications. It replaces GTD-5 exchanges with centralized softswitch-based call control and distributed media gateways and deploys FTTP in selected in-region communities.

Carriers that prefer full PSTN replacement will deliver NGN voice services earlier and more aggressively than those supplementing existing broadband network infrastructure with an NGN overlay. Carriers will develop strategies in accordance with competitive market conditions. Establishing a low-cost, application-rich NGN architecture is a key to a longer term consumer VoIP marketing strategy.

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Wojciech Michalski was born in Bogate, in Poland, in 1952. He received the M.Sc. degree in telecommunications engineering from Technical University in Warsaw in 1977. He has been with the Switching Systems Department of National Institute of Telecommunications (NIT) since 1977, currently as a senior specialist. His research interests and work are related to PSTN backbone and access networks, GSM networks and IP networks. He is an author and co-author of technical requirements and many documents concerning telecommunication networks, services and protocols.

e-mail: W.Michalski@itl.waw.pl
National Institute of Telecommunications
Szachowa st 1
04-894 Warsaw, Poland