Scenarios for the Transition to NGN

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Summary
In recent years, telecom operators have taken big steps towards Next Generation Network (NGN). Although the concept of NGN and the need to pass it, is known, but discussion on different strategies for migration still continues. The migration to NGN should be done with the best design, the lowest cost, the fastest time and the least error for operators who intend to migrate. Due to the complex nature of this topic, the main goal of this paper is to identify the common steps that telecom service providers consider to migrate to NGN, and previously published papers are intended as a basis for research. This paper covers the analysis of the capabilities of NGN, preparation steps, and migration scenarios to NGN.

Key words:
Component, Migration Strategy, Migration Scenario, PSTN, IP, IMS, NGN.

1. Introduction

Telecom service providers across the world are in the migration path towards next generation networks. Global communications and networks interaction with each other has led to the disappearance of geographical boundaries, and this has caused innovation in new products and services. The important thing in this innovation is the convergence of voice and data, creating a network that provides the services of broadband and narrowband data, and real-time services to subscribers. Around 2005, the migration to NGN became a hot topic among major service providers across the world, when the market need for new and innovative services became clear and subsequently, the telecom sector presented migration from legacy networks to NGNs to prevent customer loss and customer requirements for access to new technologies [1].

The establishment of NGN has created unique challenges in terms of its implementation and deployment. Migration from legacy networks to NGN is not a simple task and depends on the existing infrastructures, so it is necessary to have enough information about the characteristics of NGN and its differences with legacy networks. For this purpose, in this paper first the characteristics of legacy networks are analyzed from the perspective of services, technology and architecture specified by ITU-T, then the gap between legacy networks and next generation networks is explained, and after that the capabilities of NGN to support migration are discussed, and in the following the preparation steps for migration and transition scenarios towards the next generation network are described.

2. Legacy network analysis [5]

The legacy networks are the networks have been existed so far. For the migration to next generation networks, we must have information about legacy networks, and given the current infrastructures choose the right strategy for transition to NGN, so in this section we take a brief look at Public Switched Telecommunication Network (PSTN), Public Switched Data Network (PSDN), Public Land Mobile Network (PLMN) and Integrated Services Digital Network (ISDN).

2.1 Public Switched Telecommunication Network

The telephone network is the oldest, the most popular and the most extensive network in the world. This network is comprised mainly based on switching circuit. PSTN includes the following major components: switching offices, transportation facilities, customer premises equipment.

2.2 Public Land Mobile Network

As it is known, mobile network design and installation are more complex than those of fixed telephone network. In fixed telephone network, it is sufficient to provide a pair wire to a subscriber who is located in a fixed position, and then the network is activated via the electrical signals within that pair wire. But in mobile networks, it is necessary that the communications for the subscriber are established by radio, and as the subscriber can be in a new location at any moment, they must be tracked and their connection to the network be established. Mobile network is a cellular network.

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2.3 Public Switched Data Network

Public data transmission network, using the communication platform around all parts of the country, makes it possible to establish data connections between computer systems connected to it. In the user's view, this network is like a public telephone network, with the difference that instead of connecting the phone to the network and transmitting voice, in PSDN network, computer systems are connected to the network and data are sent in the form of ones and zeros.

2.4 Integrated Services Digital Network

This network technology design which is established based on a fully digital network, in fact, is trying to replace analog system with digital one which supports digital data well in addition to audio data. This means that in this type of network, transmission is in digital form. In this system, the sound is first converted into digital data and then transmitted. This network provides integrated services, which uses PSTN with a set of communication standards for simultaneous digital transmission of voice, video, data and other network services over the traditional circuits.

3. NGN capabilities for migration

A definition of NGN according to ITU-T is outlined as follows: "NGN is a packet-based network which is able to provide telecommunication services and use of broadband and transmission technologies, capable of providing quality service. Also in this network, service-dependent functions are independent of transmission-dependent functions." [5] NGN services include session-based services such as IP telephony, video conferencing, video communications and non-session services such as television broadcasting and video streaming. It also supports PSTN/ISDN replacement.

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Service coverage of NGN is due to the powerful transportation capability of this network, as a foundation to cover integrated services from simple text to multimedia contents, including audio and TV.

3.1.2 Service quality

These are the services which are expected from the end user, including guaranteed voice, guaranteed multimedia services, video conferencing and providing IP services based on NGN and other services, through interaction with existing networks.

3.1.3 Service security

NGN is required to support the security features incorporated in the existing network and secure connection with other networks. Dimensions of NGN security include access control, authentication, non-repudiation, data confidentiality, communication security, data integrity, availability and privacy.

3.1.4 Mobility

Personal mobility and terminal mobility

- Personal mobility: where users can conduct their registration mechanisms by a terminal that communicates with them.
- Terminal mobility: It is used within and among networks where the registration mechanism and support for terminal mobility with service continuity exist.

3.2 Requirements for NGN services include the following sections [13, 14]

3.2.1 Expansion of the services of NGN environment

OSE is required to enable new capabilities and support a wide range of emerging services, including services with advanced features and support third parties who provide services to developers of new applications. Also, the reusability of commercial software which is appropriate to reduce development costs is recommended.

3.2.2 Content management:

NGN is required to support various media resources and media resource management capabilities to enable a wide range of applications including recording media, uploading, inserting, media games, and speech recognition. Also, it is suggested to provide content management capabilities to manage various media resources with large contents, such as enterprise content (e.g. business documents), web service content (e.g. HTML files and images) and IPTV services [15,21].

3.2.3 Service-specific requirements

ITU-T identified attention to certain types of services such as PSTN/ISDN, talk service, IPTV services, tag-based

identification services, service delivery management, visual services of surveillance camera, omnipresent sensor networks services, and services of multimedia communications and virtual private network center.

3.2.4 The aspect of public interest:

Particular requirements for aspects of public interest should also be considered like covering legal tracking, detecting malicious communications, remote emergency communications, selecting services of the provider, users with disabilities, portability, and decentralized services.

4. Various aspects of migration

Before beginning the migration steps, various issues should be considered to exactly achieve the things essential to migrate to NGN. These issues can be explored in different dimensions. One of the most important issues in next generation networks is moving from TDM service structure of circuit network to a packet-based structure. To move towards NGNs, increase in data traffic and voice services revenue should be considered to obtain a reliable method for implementing a single multi-service network. Given the considerable investment in PSTN switches, it will be done slowly. In the IP-based transmission networks, compared with PSTN switching, core transmission is cheaper; also it offers more capability in utilizing the broadband of optical fiber and carrying package traffic. Now access network has the highest costs in the provision of PSTN services. The issues of importance in moving towards next generation networks in different countries include having strong infrastructures for IP networks in sections such as aggregation, core and essential access. To better take advantage of these infrastructures, transition to NGN seems reasonable [3].
To achieve NGN and build an IP multimedia subsystem (IMS), since the legacy network consists of many established layers, one of the purposes in network migration is to reduce network complexity by consecutively replacing layers of NGN equipment. A lot of preparation and planning should be done before the migration process, and designs, solutions and planning method should be studied to smooth the migration [1, 12].

4.1 Network evolution

Network evaluation is a starting point for migration in any network. Before planning to migrate, design or implement, existing networks should be evaluated. The evaluation includes operations of support network, equipment and resources, services of available network, carrier network signaling, network traffic, and synchronization network. According to the evaluation of the results, a strategy, a right plan and a right solution are adopted. In addition, key performance indicator (KPI) of the existing network is used as a benchmark for performance.
Following steps are used in the migration from the legacy network:

- Network migration from the old infrastructure to a new infrastructure
- Supplementary and intelligent services
- Migration of all data

Whatever strategy is chosen for migration it should pursue the following objectives:

- Reducing network complexity
- Replacing outdated TDM switches and the introduction of new NGN services
- Reducing network complexity to only three layers instead of seven layers [9]

4.2 Subheadings Preparation for migration [4]

Preparation for migration and its design is the most difficult part of the migration to NGN. Migration must be done with a high degree of attention and accuracy; otherwise the inevitable problems can occur. The approach for migration must be safe to reduce its impact on the existing networks, reduce implementation cost and benefit along the path of the migration.
For a good migration, there must be a plan for its implementation, and the following issues must be considered before the beginning of the migration:

1) Network migration layout
2) Planning data migration
3) Implementation plans of the phase
4) The plan process
5) Test, admission program and operations

The important point in the migration is to ensure that the services and information are transferred from legacy network to NGN correctly and on time. There are two types of data that must be transferred in migration: static data and dynamic data.

1) Static data: those data which are stored in each TDM switch: Controls of operators such as the number of subscribers and charging data etc. are of this category.
2) Dynamic data: those data which are modified by subscribers such as USSD.

To accurately and timely ensure the migration for both mentioned data types, a good plan is required and preparation must be already started. All data migrate from switch to NGN format; this conversion can be done automatically through a good programming.

Important suggestions on migration plan:

1) Designing the entire network topology for migration
2) A detailed plan for the availability of required equipment for NGN
3) Estimation of requirements, risks, suggestions and solutions
4) Testing applications and preparation reports for each site (hardware, software, and capability testing)
5) Planning and preparation of resources (staff, materials, vehicles, equipment, and support)
6) Performing the migration plan
7) Integration with network plan
8) Data migration plan
9) Integration with OSS
10) Integration with billing system
11) Replacing services
12) Rollback and test plan.

This plan should be devised by the top management level and after being studied by the supervisor, team leader, technical committee, and valid vendors. The most important step is the technical and practical preparation of a migration which is described here:
Performing the migration to NGN should be started by inspecting and checking TDM switches and studying the data and circumstances. Overall, preparation and adjustment process can be outlined as follows:

1) Checking environment to ensure the availability of resources, weather, conditions, and context.
2) Producing and transporting the equipment, tools, and required resources for the site
3) Installing the hardware for NGN equipment
4) Hardware inspection and acceptance testing
5) Installing the software, inspection and testing
6) Function acceptance testing
7) Integration and testing the new NGN equipment with telecommunication networks
8) Integration and testing by billing, OSS, and value-added services system
9) Ensuring a good cooperation with all network institutions
10) Data exchange services
11) Final testing and acceptance.

4.3 Migration cost

IP network investment is stated to be 50% of the investment cost of switch network, and effective costs of voice and data convergence in legacy network can be the rest 50%. One of the main reasons that leads to the movement towards NGN is the capability of this network to support the rapid introduction of new and different services. Following technical and economic factors should be considered to migrate:
Major and maintenance costs, implementation price, standards, support and the introduction of new services and innovations [11].
Important suggestion: The new system can be examined with a very small number of subscribers and performance monitoring, and if the outcome is successful, the project is expanded. To speed-up help, if faced with problems, it is recommended to use engineers specialized in the field of NGN migration to support the new and old systems. Also, to build good experiences, all actions and mistakes can be recorded and used as a reference. In the case of migration and facing with failure, rollback is the only option, but there should be enough time to rollback [8].

4.4 General aspects of migration

General aspects of migration include: capacity expansion of network core transmission, development of NGN core coverage through call server and gateway media and then connection or interaction with PSTN, installation of NGN access node for example several node access services, stop buying legacy access system, transferring those clients who want to have advanced features or a fast connection to the internet or new NGN, and services on NGN access nodes [2].

5. Migration scenarios towards NGN

ITU-T defines the evolution towards NGN (i.e. the migration to NGN) as "a process in which all or part of existing legacy networks are replaced or updated regarding the NGN components to provide similar or better capabilities, while trying to maintain the services provided by the core network and the possibility to create additional capabilities there." Therefore, to migrate from legacy networks to NGN, there are many ways which could be considered according to the environment and future prospects. In this section, various scenarios are introduced to help precise migration design [5].

5.1 General migration scenario

IP is one of the technologies to carry data used at layer 3 (i.e. network layer); also it is one of the connection elements to NGN. According to this, the first step should

be to change TDM to IP-based networks. The next step that should be considered is the network settings. In general, network migration in the core sector is easier than migration in the sector dedicated to access to the network; because it has less impact on service delivery. Figure 1 shows the general view of migration scenario. So, in general, first the introduction of the capabilities of NGN core network, and then access networks are recommended. It must also be pointed out that service networks depend significantly on mobility, so migration projects must be considered for both transportation and services networks. There are various ways to migrate from legacy networks to NGN [1].

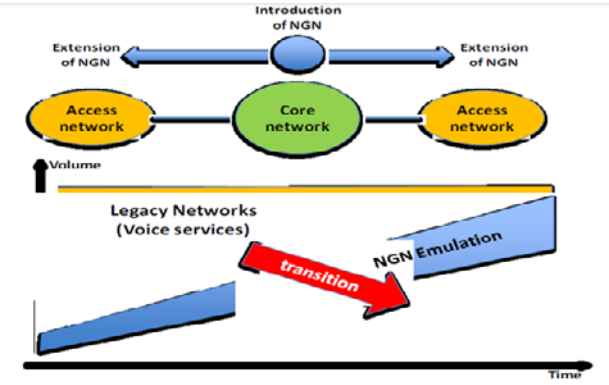

Fig. 1 General views of migration scenario [5].

6. Types of transition scenarios [5]

Generally, there are three scenarios for migration:

1) Replacement
2) Migration
3) Permutation

6.1 Replacement method

In this scenario, the network operator replaces the whole TDM network by NGN elements. NGN deployment is a crucial infrastructure for the future transformation of legacy networks. Moreover, according to user growth as well as legacy networks status and network capabilities, this replacement needs to be expanded. Through this scenario, current users, even using PSTN/ISDN continuous support and without changing terminal and operator, stop their deployment of PSTN/ISDN; and there is no need to invest in this area. In other words, in this way, all TDM elements are taken and NGN elements are entered into the network. The positive point about this method is the provision of completely new services and technologies in a relatively short time. But given that NGN network is still not proven, thus replacing the entire network, especially in large networks does not seem reasonable; on the other hand, this method requires a large initial investment.

6.2 Migration method

In this method, the existing structure of the network does not undergo drastic changes. On the other hand, in some networks which use older digital switches, the promotion of existing switches may cost more or equal to the replacement method. Due to the fact that the structure of the network does not change a lot, so the confidence level of the network does not decrease. In this method, the existing TDM switches are promoted so that they can make a connection between the users IP equipment and IP network. The only service which is provided with such a network is high-quality VOIP and low-quality video services.

The steps of migration method to move from PSTN to NGN [10]:

1) Internet access via PSTN
2) Strengthen the PSTN
3) Voice over channel Voice Over Trunking
4) Access to Voice Over Trunking
5) Provide multimedia services
6) Full transition to NGN

6.3 Permutation method

In this scenario presented to cover the deployment of NGN infrastructure with existing legacy networks, two infrastructures of NGN and legacy networks coexist, which leads to provision of advanced services while the legacy networks still exist. The TDM switches remain intact in this method and NGN network is created in parallel and the connection between two networks is established through media gateways.

7. Considerations to identify the scenario

As described in the previous section, each scenario comes with details and has its advantages and disadvantages; the appropriate scenario is considered in terms of various issues. In this section, various topics in the selection of a scenario to migrate from legacy networks to NGN are studied.

7.1 General considerations [14]

Many issues arise when creating a migration plan, so the requirements for considering different perspectives, during the installation of a migration plan, should be carefully checked. Given this, it is generally not possible to choose

the best way in the global context. For this reason, the migration should be done based on each country's position including national perspective, user requirements, political and regulatory issues, environment, technology trends and business environment such as provided conditions by the operators and industries.
As shown in figure 2, the identification domain of each different sector of the subject is summarized as follows:

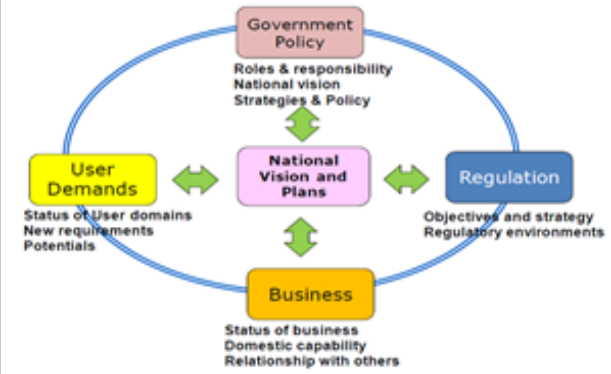

Fig. 2 The range of considerations for migration [5].

1) User demands
2) Government policy
3) Regulations
4) Business

7.2 Technical considerations

ITU-T suggests that all aspects should be carefully studied and appropriate measures taken. For better migration, following issues should be considered:
The growth of voice services market and PSTN/ISDN legacy network or NGN, continuity of services as well as compatibility with voice services, working with existing old equipment, providing new communication services for new users, offering facilities to new markets through NGN migration, providing bandwidth, infrastructure enrichment between separate access and operating system, estimating operational cost for NGN implementation and capital costs for NGN infrastructures, providing a timeline for the entire migration process and decision-making to begin the replacement of the infrastructure.
Special attention should be directed to expand services in remote rural areas. Migration to NGN in rural areas should not be sudden, and there should be cooperation between both older and newer technologies [7].

7.3 Management aspect

Management of PSTN/ISDN supports network activities based on exchange within center, network access, intelligent network and operations support systems (OSS). ITU-T states management principles for PSTN/ISDN on a recommendation. An NGN management system consists of network management, network monitoring and services management. Management functions of each layer are implemented in the layered model of NGN. Management of PSTN/ISDN migration requires the ability to support the transition from PSTN/ISDN to NGN through the middle stages. Management and maintenance operations and usability in order to evaluate network performance, and to decrease operational costs and minimize services interruption, services destruction and operation failure during migration from PSTN/ISDN to NGN, ability to detect gaps, defects and failures, such as package failure or packages inserted incorrectly, are necessary. In addition, a mechanism must be provided to indicate connection status and support performance monitoring [1,10].

7.4 Aspect of national regulatory bodies' services

This aspect includes public telephony services with the same or better quality and availability, accurate billing and charging capability, the availability of directory inquiry services for PSTN/ISDN and NGN users, support for emergency telecommunications, support for all users, provide at least the same support functionalities of PSTN/ISDN. It should provide mechanisms to support lawful interception and monitoring of various telecommunication media such as voice, data, video, email, messaging, etc. to access contents of telecommunication. Such a mechanism can be provided from a network content provider (CT) and intercept-related information (IRI) by law enforcement agencies (LEA), to satisfy the requirements of the government and the international treaties [5].

7.5 Status of legacy networks [5]

One of the most important factors during the process of migration planning is the exact status of legacy networks including related infrastructures to support the network and services. For this reason, the information collected about the status of legacy networks such as fixed and mobile legacy networks are analyzed here. Information collected on the status of legacy networks are as follows:
Fixed network infrastructures, existing DSS (Digital Switching System), status of copper cables, status of telecom operators, and internet and broadband infrastructure.
The followings are most useful to achieve the intended objectives:
Studying legal and regulatory telecommunication regimes and identifying these elements in order to accommodate convergence and compatibility, collecting the expectations of operators and service providers of NGNs, investigating migration strategy from large operator of fixed and mobile

phone about core and access networks, identifying elements which prevent or increase migration to NGN (in the technological, economic and regulatory level), identifying new economic models with NGN, setting an strategy to migrate fixed and mobile phone networks to NGN.

The proposal for migration is an ambitious roadmap in which the compatibility with the new technological changes, along with the budget, the actual realization deadline and an indicator monitoring mechanism over their implementation are essential. This subject should be carried out according to the following suggested steps:

1) Collecting and analyzing information on a legal framework and monitoring telecommunications
2) Collecting a set of information from fixed and mobile phone operators, internet access and service providers
3) Analyzing and utilizing data on the situation of each country and comparing them with the experiences of other countries
4) Preparing a roadmap, and generating a final investigation report and strategy document for transition to NGN

7.6 Scenarios selection [5]

Finally, according to what mentioned above, which scenario looks good?

7.6.1 Permutation scenario

Permutation scenario in the country or an operator with a stable PSTN/ISDN infrastructure is useful. Through this scenario, operator gradually gets prepared to provide adequate resources for the next investment while keeping their clients in an optimum state. In addition, the operator, using the advanced capabilities provided through NGN, satisfies the needs of the users. Regarding the increasing number of users who wish to use advanced capabilities, the operator expands the NGN coverage and therefore reduces the existing clients in legacy networks. In this case, NGN users communicate with users of PSTN/ISDN network using their simulations through the interaction between NGN and PSTN/ISDN.

7.6.2 Replacement scenario

This scenario is useful for a country or an operator which does not have enough PSTN/ISDN infrastructures. This procedure is difficult to continue the deployment of PSTN/ISDN equipment because it requires new investment, while investment in NGN is also necessary. In this scenario, the operator stops its deployment of PSTN/ISDN and the investment flows to NGN, and eventually all users are covered entirely by NGN capabilities.

8. Conclusion

The telecom industry is rapidly changing. Thus, to compete in the market and prevent the loss of customers, the operators try to find new ways to maintain and increase subscribers and satisfy user expectations and services. According to the subjects mentioned in this study, the best way to integrate voice and data services in the packet-based networks is NGN. The important point here is how to implement the strategy and scenario for transition from the existing network; as indicated in different sections of this paper, it depends on the existing infrastructure in each country, and the appropriate decision must be taken regarding the conditions. After doing research in this field, it is discussed which scenario is more appropriate for Iran: The best way to achieve NGN in our country is permutation method. As mentioned earlier, in this scenario, the network architecture is preserved and besides keeping existing ISDN/PSTN network infrastructure and services, a new network is installed. Thus, according to the existing infrastructures in Iran and the budget for the implementation of next generation networks, the permutation method seems more appropriate. As a future work, we are planning to optimize the quality of service (QOS) in NGN with evolutionary optimization algorithms such as genetic algorithm, particle swarm algorithm, imperialist competitive algorithm, and cuckoo optimization algorithm [16-20].

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