Introduction:

This chapter compares the technical aspects of interconnection, specifically it explores the weaknesses of the existing interconnection technology which is based on TDM. Furthermore, this chapter explains the advantages of IP interconnection techniques. Finally after a detailed comparison this chapter propose an Optimum Aspects for Sudan Telecommunication's Interconnection Networks.

NGN offers reduced network and operational complexity resulting in better and reliable service.[16]

It offers unrestricted access by users to different service providers also supporting generalized mobility. In the course of transition from the legacy PSTN to an IP based NGN there are many issues which need to be addressed. This chapter also gives the benefits that the service providers and the end users are expected to gain as a result of NGN deployment. We have also put forward the scenario of NGN implementation in order to have a faster transition from the legacy PSTN. In old TDM interconnection system there are many problems , Include:

- Synchronization
- Signaling
- Congestion
- Trunk busy
- Wrong routing
- Lack of planning
- Lack of traffic forecasting
- Lack of network protection and safety

- Lack of agreement for some services, and
- Transmission Specification problems.

Some of the above mentioned problems will be discussed in detail in the following sections while the rest will be explored in table 3-2

3.1 Synchronization:

Because Sudatel and Zain using synchronous digital hierarchy (SDH), so synchronization must be Important to avoid the problems coming from poor synchronization. But the networks for both Sudatel and Zain are not well synchronized, and so they are some problems and must be resolved by the new interconnection system. (Refer table):

Table 3.1 Show The Failed Calls Due To Synchronization*

Outgoing traffic from Sudatel to Zain	**Total calls**	**Failed Calls due to Synchronization**	**Percentages**
ITC2 (International)	42,897,428	7,951	.02%
ITC2 (national)	153,941,360	11,472	.007%
As average percentage of total outgoing calls	**196,838,788**	**19,423**	**.009%**

Source: [3]

Data is taken from table 3.1

Because Sudatel and Zain using synchronous digital hierarchy (SDH), so synchronization must be Important to avoid the problems coming from poor synchronization. But the networks for both Sudatel and Zain are not well synchronized, and so they are some problems and must be resolved by the interconnection agreements. The two parties can agree to use the same type and source of synchronization due to special agreement for synchronization.

There is no written agreement between the two parties concerning the synchronization.

All the above points must be a subject of negotiation between the two parties and later included, in detail, in a written agreement according to other's international interconnection specifications and conditions, and NTC conditions.

3.2 Signaling:

Using R2 or SS No.7Signalling System Numbers 7(SS No.7) is now widely used. SS No, 7 standards aim at defining Signaling procedures and architectures in circuit Switched networks: PSTN, ISDN, GSM and IN.

Telephony User Part (TUP), which defines the formats and signalling procedure to be used for Public Switched Telephone Network (PSTN) calls and integrated service user part (ISUP), which define the formats and signalling for the Integrated Service Digital Network (ISDN) and Global System for Mobile Communication (GSM) basic calls and supplementary services. These standards are appropriate for the Interconnection of different network in the same country for the provision of fixed or mobile voice telephony services.

In this section we review the main different between TDM interconnection system and IP interconnection.

3.3 Comparing between current interconnection and IP interconnection :

Features and disadvantages of old interconnection system and comparing with new proposed interconnection, table 3.2 explain that:

Old interconnection system(Switching telephony networks)	IP interconnection system (Next generation IP networks)
Circuits dimensioned for voice	Traffic types vary (different QoS needed)
Interconnection fees based on time	Packets have no time or distance dimensions
Fixed-mobile interconnection asymmetric	Packets exchanged uniformly across platforms
Small but constant information delivery rate	Typically “burst”traffic pattern
Little tolerance for delays and sound distortions	Handle time sensitive and delay tolerant traffic
Regulated interconnection at agreed POIs	Unregulated peering and transit
Traffic routed over a circuit to dialed number	Connection less “best efforts” routed on IP headers
Big number of resources	Low resources need (IP)
Difficult to monitor	Easy to monitor all the systems
Complicated in linking and interconnect	Easy to connect and add new link
Long time need to do expansions	Short time needed to extend
Using as carrier only	Use as access and core
Charging un accurate	Use many types in charging – accurate billing
	Ensuring in transparency in charging operations

	Direct IP inter-connection between Operators, national transit IP interconnect and service level aspects for next generation corporate network IP interconnect (peer-to-peer business trucking).
	Ensure that requirements are identified for the identify relevant existing specifications, initiate enhancements and the development of the new specifications.
Telephony	VOIP
TDM	IP Transport
ISUP,MAP,TUP,SS7,R2	SIP protocol,H248,H323,Sigtran
	Ensuring to enable new IP services :video, presence, IPTV, messaging,…
	Simplicity of the integration & operation
	New revenue stream
	Future proof investment, 100% support of convergent network.
	Improve customer retention
	Compliance with telecom standards.
Synchronization problems	Not found problems in synchronization
Congestion	No congestions
Trunk busy cases	Wide Band bandwidth

Wrong Routing	Alternative routing
No planning	Planning to high traffic to long time
Lack of network protection and safety	Protect network
No agreement for some services	Agreement for all services.
Problems in billing& charging	New system in billing IN,OCS,OfCS.
Through satellites ,microwaves ,VSAT	Submarine cables ,IP Backbone
In international interconnection ,need OPC and DPC	In international interconnection, need IPs

3.4 Technical Challenges:

Core TDM networks can include thousands to millions trunks for transporting voice between circuit switches. For example, fixed line providers may have large tandem switches to interconnect many local exchange nodes. Other providers in Sudan like mobile operators, may simply use a mesh of trunks between switching centers. The biggest technical challenge for service providers in replacing these expensive switching networks is finding VoIP control and switching platforms that can replicate their existing TDM network services. These new platforms must provide a full array of advanced routing and termination services , such least cost and time-of-day routing ,to enable network cost savings and new services that justify the migration. The platforms also must support national and international signaling and protocol variants, and provide the assurance of carrier class equipment to replicate the high reliability of their TDM networks. Increase of subscriber numbers interconnection faces many challenges and we need to do optimum technology to provide interconnection and to migrate to new generation of technical and operational systems with high availability and new features of interconnection that technology is Next Generation Network (NGN) and new offers from TDM linking to IP interconnection and IP features. Developments towards Next Generation Networks (NGN) have a strong impact on the design of the markets for electronic communications in general, but specifically on inter carrier relations with respect to interconnection and access. Due to the fact that competition in the telecommunications environment has brought about alternative providers and their business models it is an interesting area to investigate how these business models will develop in an NGN environment and which (additional) business models may emerge in the future. To that end, the current proposal looks at the development of different business models in the PSTN world now and likely developments in the NGN world. This leads to conclusions with respect to requirements of the future regulatory framework of next generation networks in order to maintain the achievements of competition in the telecommunications area.

3.5 Evolving from Circuit-Switched Telephony to NGNs:

Considering that it is not cost-effective to manage different networks for different services, telephone network operators have begun evolving toward the NGN. The main argument behind migration is the possibility of reducing network operation costs, and technical problems in current interconnection. Both fixed and mobile core networks are integrating within a single NGN core network. Therefore, as in the case of plain Telco networks, there may be no difference among interconnection principles between mobile and fixed core networks in an NGN.

The importance of interconnection cannot be overstated, particularly in the evolving era of Internet Protocol-based (IP-based) networks. After all, the “poster child” of all IP-based networks – the Internet itself – was teethed and weaned on open architectures, common protocols, and massive peering and transit relationships that have eventually spanned the globe. In a basic sense, then, interconnection is the founding ethos of IP-based networks: they exist to interconnect. The trick, of course, is translating the global to the local – that is, allowing the theoretical ease of IP interconnection to flourish in an environment of privately owned, proprietary networks. Interconnection is, after all, not just a technical arrangement among different network elements. It is also a business arrangement and a regulatory challenge, particularly because of the way IP-based networks are developing out of legacy models.

3.6 Emerging challenges to IP network interconnection:

A number of factors suggest that fixed and mobile switched interconnection and IP interconnection will all need substantial re-thinking in the years ahead, and serve to motivate the current study. Among them are:

•The decoupling of the network from the service, which is a manifestation of convergence;

•The migration to Next Generation Networks (NGN);

•The evolution of the access network to an all-IP basis; and

•The changing cost structure of the network.

Circuit switching is a methodology of implementing a telecommunications network in which two network nodes establish a dedicated communications channel (circuit) through the network before the nodes may communicate. The circuit guarantees the full bandwidth of the channel and remains connected for the duration of the communication session. The circuit functions as if the nodes were physically connected as with an electrical circuit.

The defining example of a circuit-switched network is the early analog telephone network. When a call is made from one telephone to another, switches within the telephone exchanges create a continuous wire circuit between the two telephones, for as long as the call lasts.

Circuit switching contrasts with packet switching which divides the data to be transmitted into packets transmitted through the network independently. In packet switching, instead of being dedicated to one communication session at a time, network links are shared by packets from multiple competing communication sessions, resulting in the loss of the quality of service guarantees that are provided by circuit switching, figure 3.1shows circuit switching network.

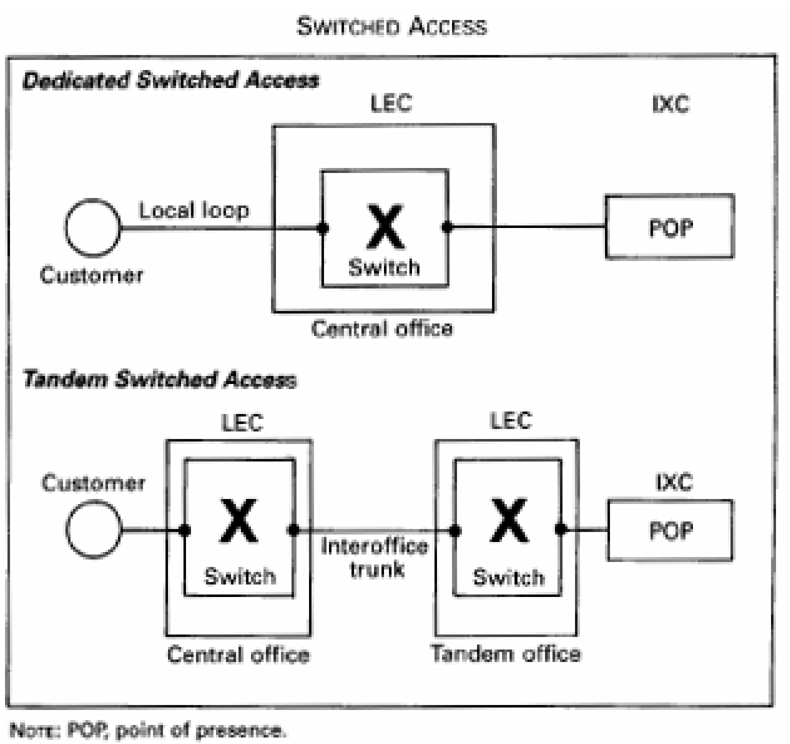

Figure 3.1 TDM, Circuit switch network, Source: [12]

3.7 IP exchange:

IP interconnection is a telecommunications interconnection model for the exchange of IP based traffic between customers of separate mobile and fixed operators as well as other types of service provider (such as ISP), via IP based Network-to-Network Interface.

The intent of IPX is to provide interoperability of IP-based services between all service provider types within a commercial framework that enables all parties in the value chain to receive a commercial return. The commercial relationships are underpinned with service level agreements which guarantee performance, quality and security.

It may not be evident to end-users whether their service provider utilizes the IPX model or not, however, the ability for service providers to differentiate services using the flexibility provided by the IPX model, ultimately provides for end-user choice, figure 3.2 show IP exchanges:

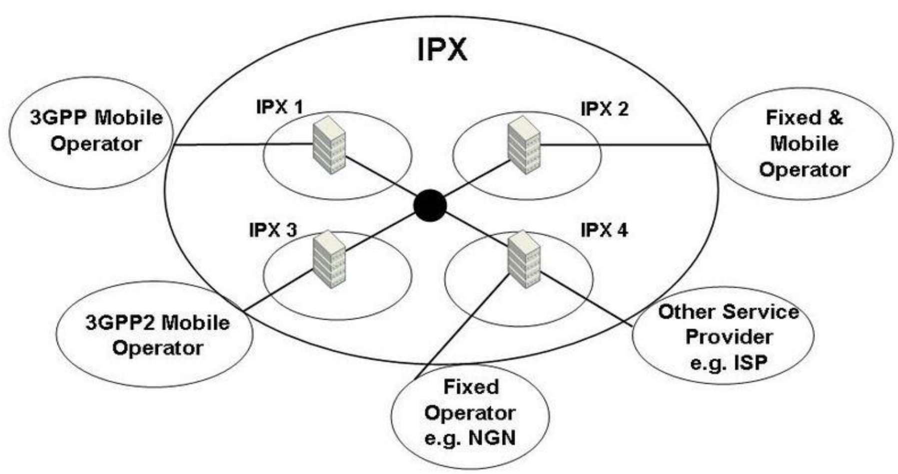

Figure 3.2 IP exchange Source: [12]

Traditionally, voice traffic interconnection between different operators has utilized the international SS7/TDM networks. However, new interconnection to all-IP paradigm with VoIP is being rapidly introduced by new technology in various forms, such as IMS and NGN. In order to minimize the number of conversions between packet-switched voice and circuit-switched voice there is a clear need to deploy an IP based NNI (Network-to-Network Interface) and therefore an IP based interconnection network. It is also evident that a large number of IP based services (such as Presence or IM) simply cannot be interconnected using a SS7/TDM network, further increasing the need for evolution into an IP based interconnection network.

3.8 Migration to NGN interconnection:

An NGN delivers a wide range of services, including the full range of capabilities that we expect from TDM to IP interconnection networks. Notably, an NGN is IP-based. Thus, the migration to NGN potentially represents a major acceleration of the trend to base future electronic communications on IP. Moreover, it is sometimes associated with plans to phase out the existing PSTN altogether.

The physical facilities that support traditional fixed and mobile switched interconnection today would not necessarily exist in these NGNs unless regulators insist that they be maintained.

IP-based interconnection facilities could potentially be much more concentrated than PSTN interconnection facilities. Only a handful of points of interconnection (PoI) are strictly necessary from a technical and economic perspective, perhaps as few as three or four. By contrast, there can be hundreds of PoIs for the PSTN. This potentially implies a complex transition for competitors, and possibly some stranded investment. A number of regulatory proceedings have considered the reduction in the number of Points of Interconnection (PoIs), but they have tended to focus on this problem in the context of access rather than interconnection. It manifests slightly differently for interconnection.[6]

3.9 NGN interconnection:

This decoupling of network and service has profound implications for regulatory policy. Regulation of interconnection has implicitly depended on a close relationship between the network and the service. The standard mechanism for inter carrier compensation depends on wholesale payments from the service provider originating a call to the service provider terminating the call in order to compensate (primarily) for the use of the network used to terminate the call. If the terminating service provider happens coincidentally to be the same as the terminating network provider.

If, however, these are different corporate entities (as is explicitly envisioned in the definition of an NGN), then it is difficult to see how a system based solely on present paradigms could possibly function going forward. For example, the customer might have a contractual relationship with an NGN network operator to obtain broadband Internet network access, and a separate contractual relationship with a third party VoIP service provider (that does not operate a network of its own), but these two providers will not necessarily have a contractual relationship with one another. [11]

An NGN interconnection mode can be direct or indirect. Direct interconnection refers to the interconnection between two network domains without any intermediate network domain. Indirect interconnection at one layer refers to the interconnection between two network domains with one or more intermediate network domain(s) acting as transit networks. The intermediate network domain(s) provide(s) transit functionality to the two other network domains. Different interconnection modes may be used for carrying service layer signaling and media traffic.

3.10 Changing cost structure:

All indications are that the emerging IP-based networks when fully deployed will have lower operating costs than existing circuit switched networks. Indeed, that is a key driver to migrate an existing network to an IP base.

I n the nearer term Sudatel in the midst of transition will simultaneously bear the costs of both the old network and the new. On a unit cost basis, their operating costs will not be as low as the eventual operating costs when transition is complete. In fact, it is possible that operating costs will increase before they decline.

3.11 Regulatory objectives:

Key regulatory objectives include:

- Ensuring that users derive maximum benefiting terms of choice, price, and quality.
- Ensuring that there is no distortion or restriction of competition; and
- Encouraging efficient investment in infrastructure, and promoting innovation.

3.11.1 Underlying drivers of change:

In context which changes are taking place, distinguishing between shorter term phenomena and longer term (the latter being out to 2018). Key drivers are noted: separation of service from network, progressive improvements in price/performance, the migration of services to IP, the deployment of NGNs, changes in the access network, and so on. Broader effects, such as changes in home networking and the increasing use of user-provided content are also addressed. Finally, we attempt to distinguish likely short-term, medium-term and long-term developments.

Some of the most important changes underway include:

• The decoupling of the service from the network: In contrast to telecommunications networks in the past, services and the connectivity needed to provide them in the future need not be provided by a single integrated firm.

• Ongoing price/performance improvements due to Moore's Law are enabling better, faster and cheaper communications by fiber optic transmission (e.g. DWDM) and optical switching and cross-connection. Break through share also possible in the years to come, but their exact nature is difficult or impossible to predict.

• The fundamental changes in the delivery of voice and video services evolving to IP- based networks. Video is migrating to IP much as voice is, but the implications are not necessarily the same. Video has enormous bandwidth demands, unlike voice; however, much video use is unidirectional. Not all video will migrate to IP; conventional cable television and satellite are very efficient media for delivering linear video to multiple subscribers. To the extent that video is indeed carried over IP, there are significant implications for network design.

• Network operators must replacing traditional circuit-switched networks with IP-based Next Generation Networks (NGNs).

• Communication protocols used for IP routing between independently managed networks (Autonomous Systems, or *(*AS) will continue to evolve and improve, which will facilitate the ability of the Internet to grow and to scale.

• IP address exhaustion and gradual deployment of IPversion6 (IPv6) is likely to become a significant concern over the next few years, with probable exhaustion of IPv4 addresses in the 2013-2015 time frame. The generally accepted solution, migration to Ipv6, has seen only scant deployment to date.

• Network back-haul in carrier core networks has historically been accomplished by dedicated circuits and Asynchronous Transfer Mode (ATM).In the future, these communications are expected to be implemented to an increasing degree by means of enhanced "carrier grade" versions of the Ethernet Local Area Network (LAN). Ethernet equipment is simpler and less expensive.

• Network operators are deploying fiber progressively deeper in the local loop, i.e., closer to the customer's premises.

3.12 De-coupling of the service from the network:

Here discuss these developments from the perspective of the Internet Protocol (IP) in general; Discuss the same developments in a Next Generation Network (NGN) context.

The following figure 3- shows that from a functional perspective a NGN basically consists of four different layers: the access and transport layer, the media layer, the control layer, and the network service layer, Figures 3.3 and 3.4 showing NGN layered structure.

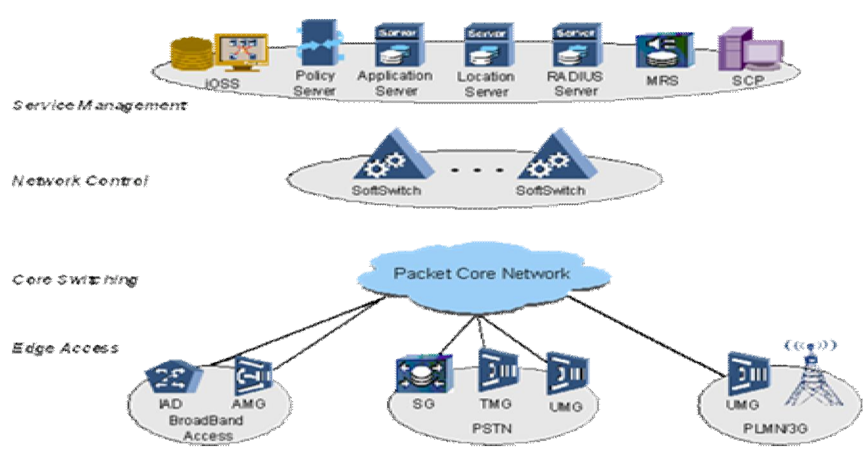

Fig 3.3 NGN layerd-1 , Source: [12]

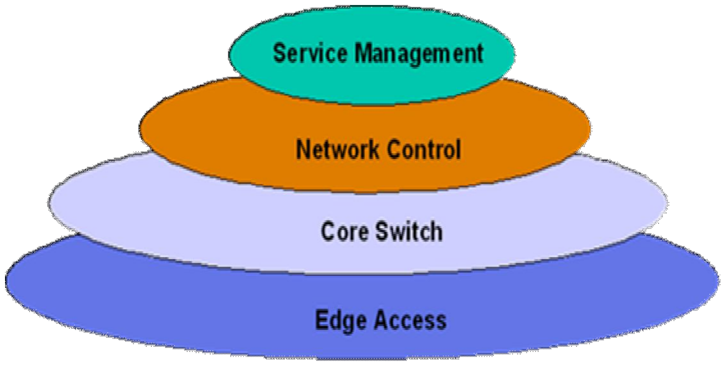

Fig 3.4 NGN layerd -2- Source: [12]

The key element of an NGN (apart from the transport function) are soft switch functions, provided either by a central unit (call server or media gateway controller) or distributed over various functional elements (Proxy-, Interrogation-, Serving- Call State Control Functions) in the IMS frame, which are responsible for signaling and the control of resources in the network. The control functions can be specified as follows:

- Call control
- Media Gateway
- Service Control

3.13 Migration of voice to VoIP:

ThemigrationoftraditionalTDMbasedvoicetraffictoIPbasedtechnology is already under way in many countries of the world. Several business models can be observed, which can be explained on the basis of Figure3.6

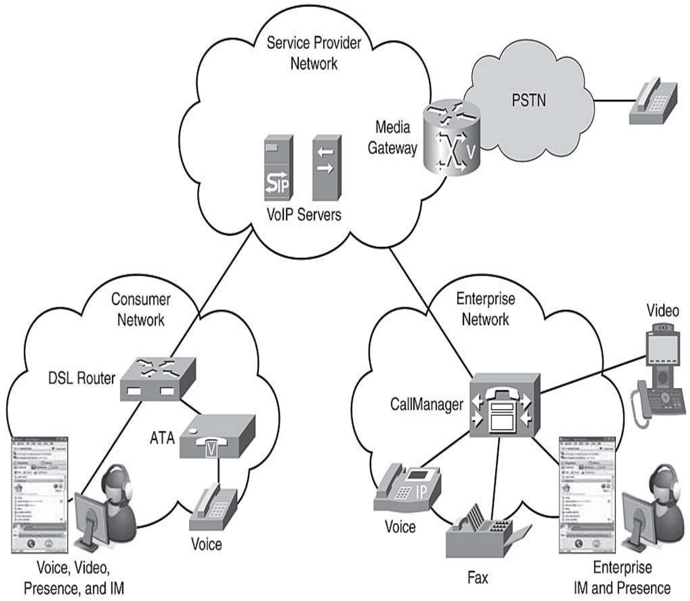

Fig: 3.5 business models - Source: [12]

Conclusion

By referring to table 3.2 and figures 3.3, 3.4 and 3.5 it is strongly recommended for Sudan operator networks for telecommunications to transfer from TDM interconnection to IP interconnection.