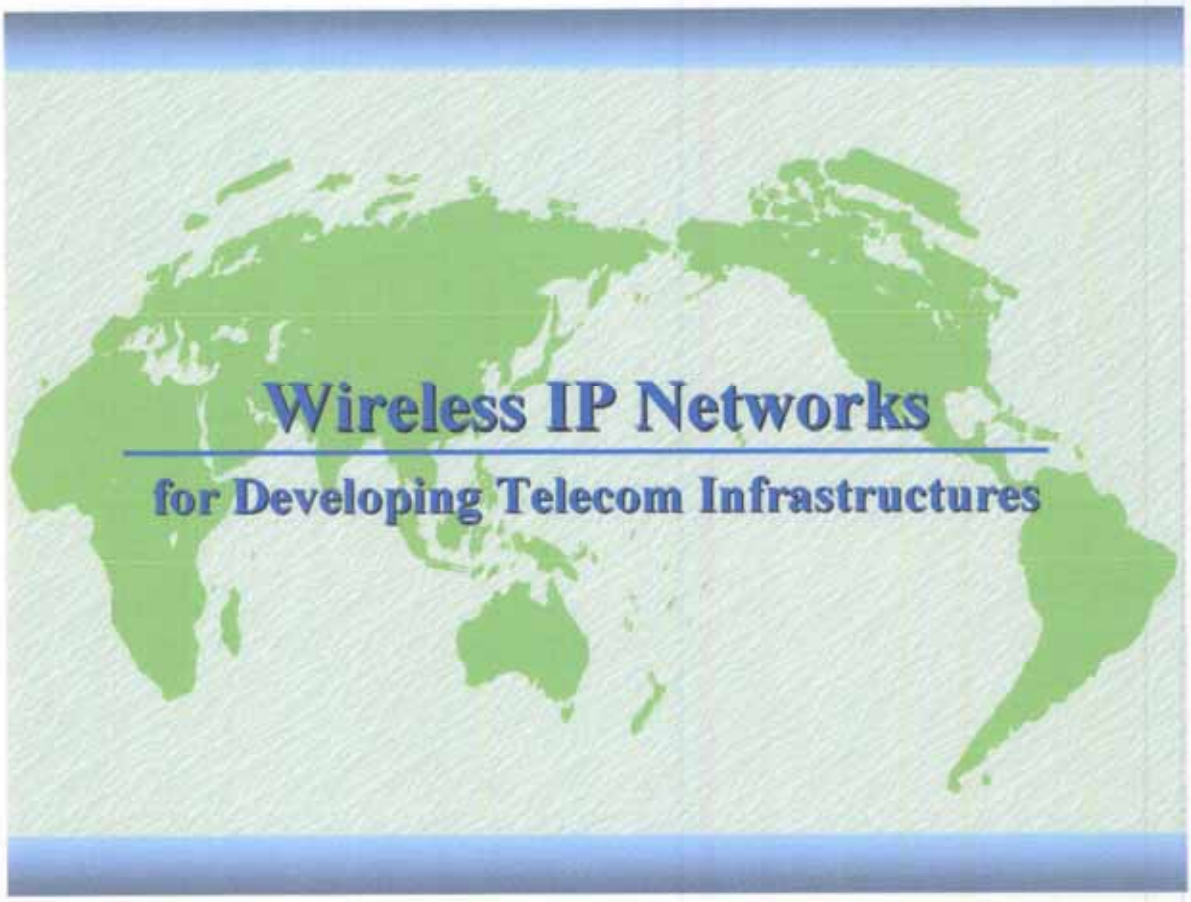
6. Rural Telecommunication Systems

6.7 Wireless IP Networks



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Introduction

1. Introduction

This session of 'Wireless IP Networks for developing Telecommunication Infrastructures' explains current topics of Wireless IP networks such as the network migration from the existing to IP-based network, microwave radio systems enhanced for IP traffic, voice over IP (VoIP) and others to help your basic understanding of microwave radio systems updated for planning to develop the telecommunication infrastructure.

In Section1 'Introduction', trends of telecommunication traffic and necessity of network migration are described, together with the explanation about network configuration, radio frequency and so on, to outline the following sections.

Section 2 'Migration to IP-based Network', explains how the networks are changing from the existing network to IP-based network and what the basic technologies are applied in the microwave radio systems.

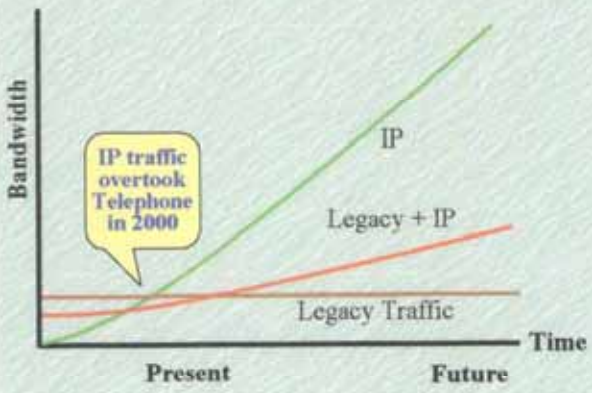
In Section 3 'Wireless IP Systems', some examples of microwave radio systems are presented to explain the practical application of technologies.

As one of the most important services, the voice transmission on the IP-based network is outlined in Section 4 'VoIP'.

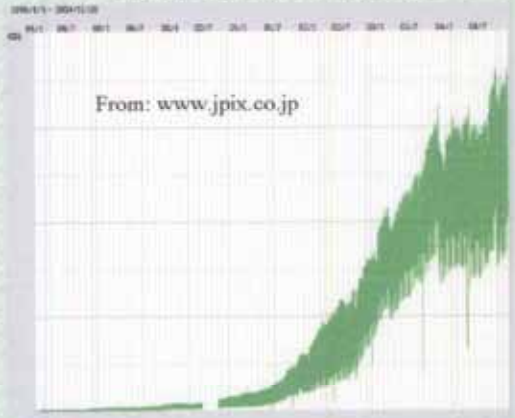
In Section 5 'Conclusions', the wireless IP systems are summed up and some recent trends are introduced.

Telecommunication Traffic Trend

IP Data is going to dominate over the telecommunication traffic



Daily Traffic (maximum and minimum) on JPIX (JaPan Internet eXchnage) backplane in bits per second



Unprecedented Volume of IP Traffic needs the huge-capacity and reliable networks → To build the Broadband IP-based Backbone and Access Networks

1.1 Telecommunication Traffic Trend

The telecommunication traffic of the domestic and international backbone networks in most of the countries nowadays indicates a distinguished trend as shown in the chart of on the left-hand side. That is a tremendous increase of Internet-related traffic, which has overtaken or is going to overtake the traditional telephone traffic.

The legacy traffic in this chart means the traditional telephone and other traffic, of which volume stays nearly constant and tends to decrease. On the other hand, IP traffic which means the traffic based on the Internet Protocol (IP) Suite is rapidly increasing. The legacy plus IP traffic means the IP traffic carried through the legacy networks. This is now overtakes the legacy traffic. Then, there are lots of planning to convert the legacy network to IP-based network to carry the IP traffic efficiently and economically. It is said that, sooner or later, the IP traffic through IP-based network will dominate the telecommunications world.

The IP traffic at one of the Internet Exchange Providers of Japan, JPIX, proves the trend clearly as shown in the chart on the right-hand side.

Since the features of Internet traffic is different from the telephone traffic, the designs of networks have been changed. One of features is the statistical traffic property. For example, both inbound and outbound of telephone conversation is considered symmetrical. Internet traffic, on the other hand, is rather asymmetrical. Day profile of traffic demand is also different.

Thus, the migration to IP-based network is unavoidable and much more capacity and higher speed in network are needed to process IP-traffic, though the huge asset of legacy networks are heavy burdens for most of traditional network operators.

Legacy to IP-based Network

- **From De jure to De facto and Forum Standard**
  - ITU to Venders (e.g. Microsoft), Forum (e.g. IETF) and etc.
  - Market Trends
- **Multimedia Integration**
  - E-mail attached with files
  - Websites with variety of media
  - VoIP, Video and Others
- **Borderless / Ubiquitous**
- **Competitions**
  - Last one mile (or First one mile) in Network & Service Providers
  - Contents in Service Providers
  - Equipment in Manufacturers

1.2 From Legacy to IP-based Network

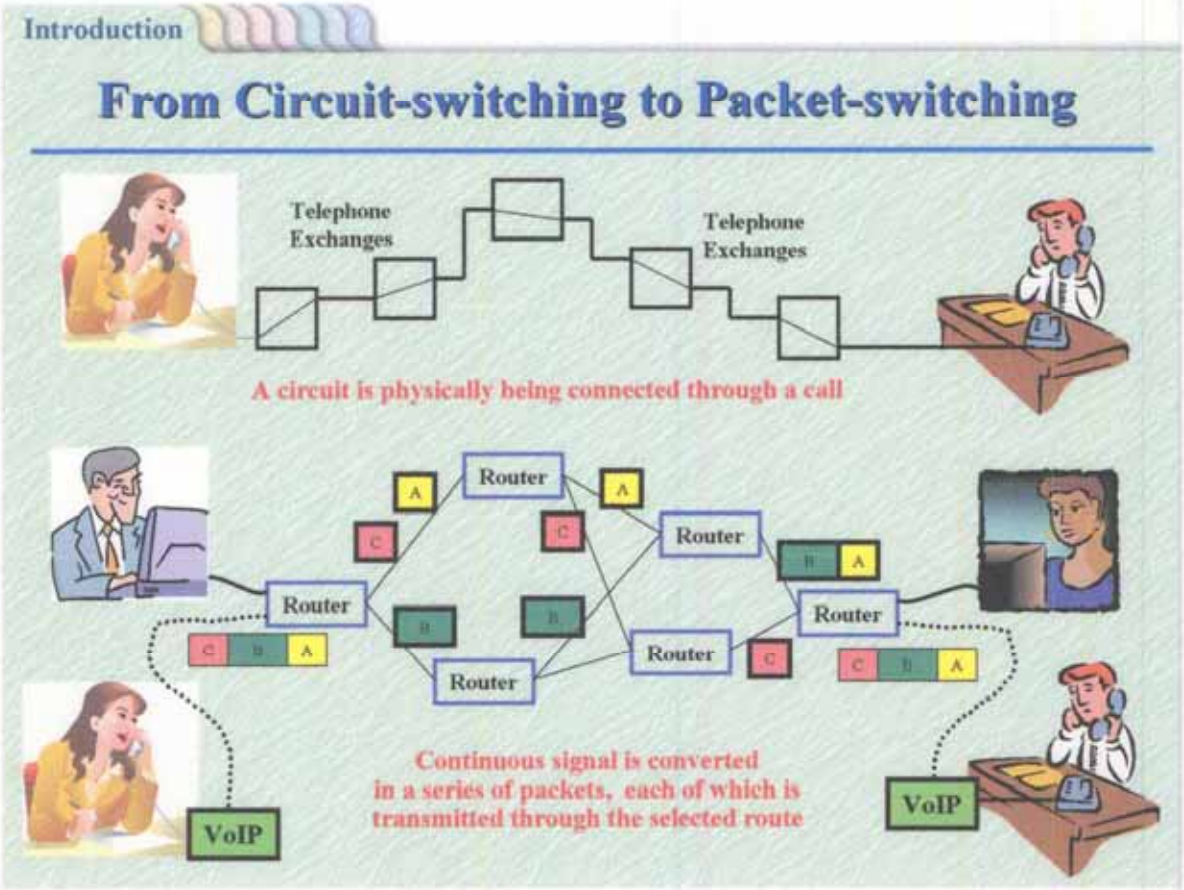
The trend and its features of changing from traditional telecommunication networks to IP network are explained with the following key words;

Standards or specifications of networks and equipment are tending to be based on De facto standards, changing from De jure or the existing regulated standards. Hardware and software vender's or Forum standards such as IETF (Internet Engineering Task Force) which has been discussing the Internet engineering specifications, so-called RFC, are quite influential. This is really based on the market winners of networks, systems, equipment, software and so forth.

Multimedia integration had been one of the main targets for the telecom world for a long time. Once the ISDN seemed promising but it has become obsolete. Internet technology based on TCP/IP has swiftly achieved an ideal multimedia integration. We can now enjoy e-mail with various attached files, various types of media in website information and so on.

Borderless has been realized spontaneously by Internet, while we used to divide the networks as the domestic part and international part. The Internet throw away the border without any difficulty. And users can have the **ubiquitous** products and services anywhere, anytime on the globe.

Competitions become severer and severer in every arena due to open and borderless markets. Network Providers have to migrate their network quickly to meet the demand of broadband IP access as well as to modify the backbone networks efficiently for huge-volume of IP traffic. Service Providers have to create more attractive contents in Internet and Equipment Venders have to develop swiftly new value-added products.



1.3 From Circuit-switching to Packet-switching

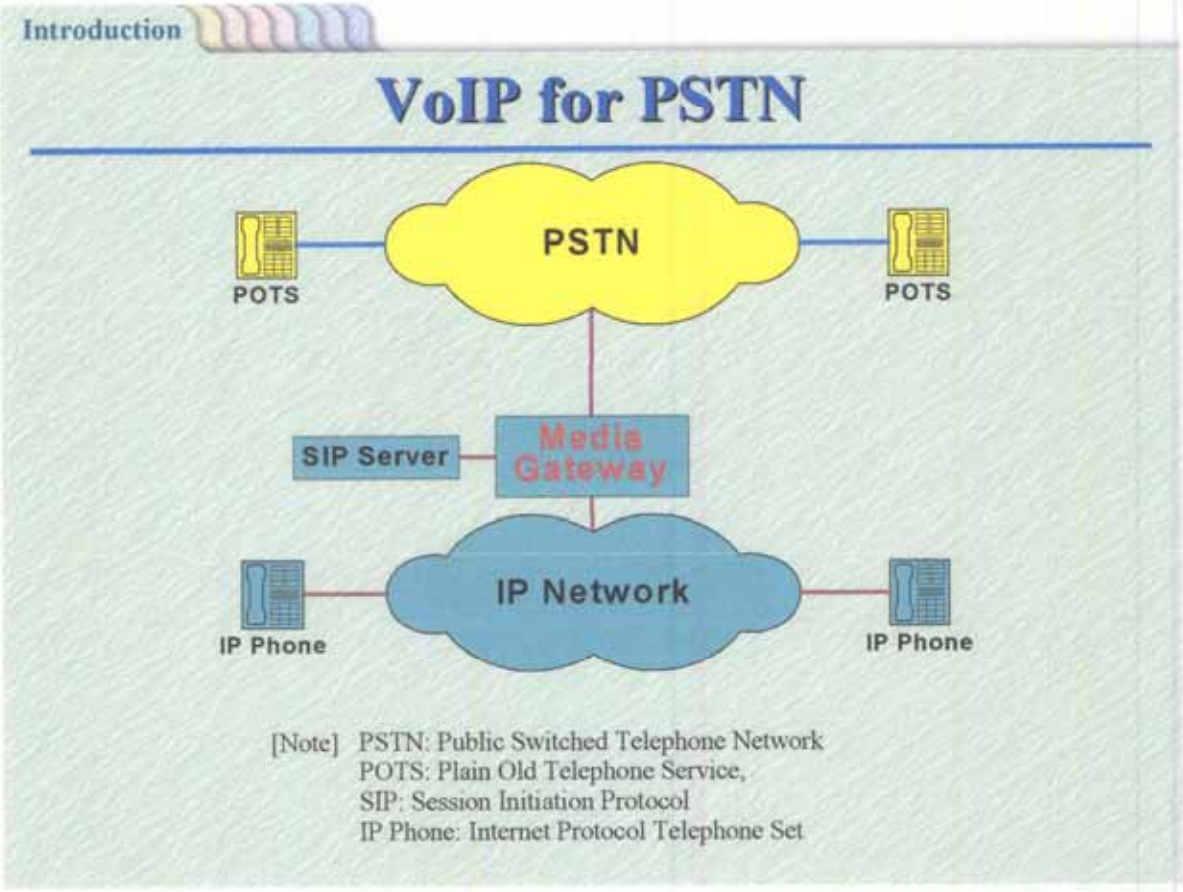
Present telephone exchange scheme is defined as the circuit-switched network, because the circuit connected at the call setting is kept through the call. The hierarchy of telephone exchanges establish the circuit to connect the calling party to the called party at far end.

It was realized not efficient to occupy a circuit physically through a call, because there are some blank periods during a telephone conversation.

Various ideas to improve this deficiency have been implemented. Among the various ideas, the packet-switched network implemented in the Internet is considered the most promising technology, nowadays.

Transmit signal is divided into packets, which are sent individually. Each packet has the destination address and goes through the independent route selected by the routers. The packets are transmitted efficiently, sharing the circuits with other traffic. On top of that, the packet can contain not only data of PC but also any kind of digitalized signal such as voice, i.e. VoIP and others.

	Circuit Switching	Packet Switching
Connection	Connection oriented: logical connection for the duration of a call	Connectionless: no logical connection, packets take different routes between the two users
Implementations	- Public Switched Network (PSTN): analog - Integrated Services Digital Network (ISDN): digital	- Packet switched network X.25: first generation of packet switched data networks (ITU-Recs X....., 197..) - IP networks: switching of packets with variable length
Signaling Systems	Analog: CCITT-SS#.....6, Digital: ITU-SS#7	IP-Protocol
Key Performance Parameters	-Analog: delay, noise -Digital: bit errors, phase jitter and wander (phase variations)	Packet Delay, Packet Loss, Bit Errors, Phase Jitter and etc.



1.4 VoIP for PSTN

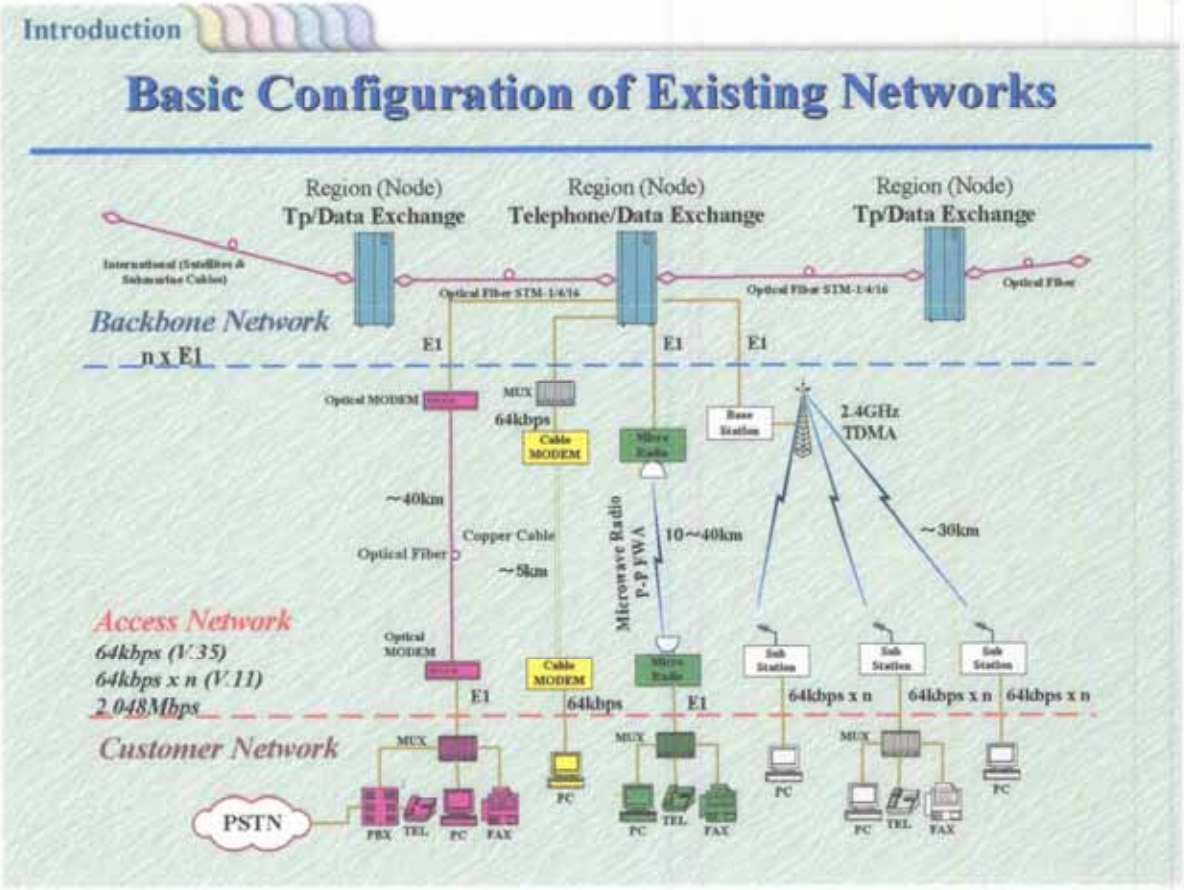
Since there are still great number of telephones connected to the circuit-switched network, it is necessary for VoIP to be connected to the PSTN from the IP Network. This is a technology required transitionally while both networks exist. One of schemes is done as shown here with 'Media Gateway and a special server called SIP Server.

Before going in depth to VoIP explanation, it would be prudent to take note of the ITU definition of IP Telephony (Internet Protocol Telephony) as follows:

> "IP Telephony" is the transmission of voice signals over packet-switched IP-based networks. There are two main subsets:
>
> "Internet Telephony": using the public Internet;
>
> "Voice over IP": using private, managed IP-based networks, in addition to the Public Internet.
>
> "IP Telephony" is also used as a generic term to cover Fax over IP, Voice over Frame Relay, Voice over xDSL etc,. Relevant ITU-T standards include H.323, H.324, H248, T.120 etc.

That is, the challenge in IP Telephony is to deliver the voice, fax, or video packets in dependable flow to the user. While most consider IP Telephony to be the movement of real-time VoIP, IP Telephony actually embodies much more than VoIP.

In this Session, some technology issues of VoIP are touched on and its rapidly changing trend is explained.



1.5 Basic Configuration of Existing Networks

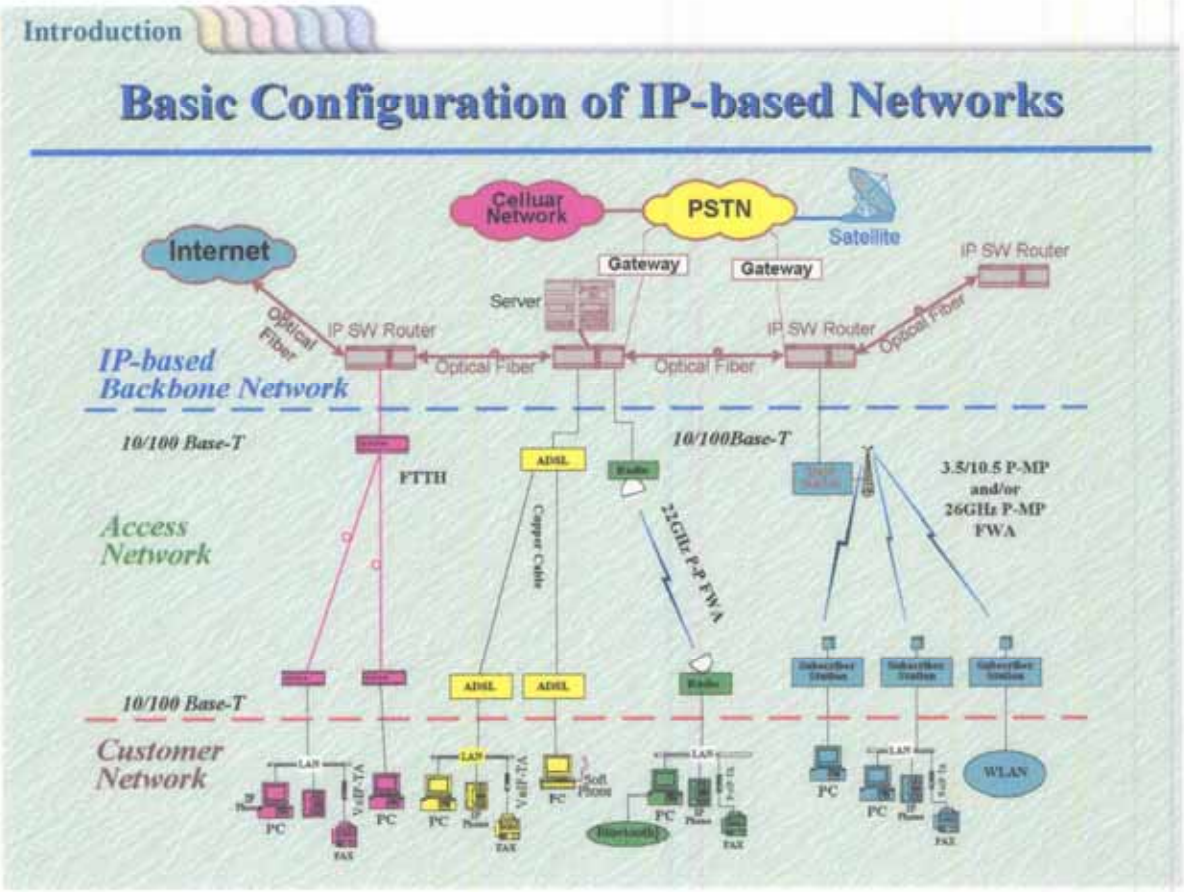
Let's review a typical block diagram of existing data communication network. In general, the telecommunication network consists of three parts, namely Backbone Network, Access Network and Customer Network.

Backbone Network currently consists of the Telephone Exchanges at each center and the optical fiber SDH connection between them in the case of telephone transmission. For the data transmission, similar configuration exists with the Data Exchanges at each node, instead of Telephone Exchanges, as shown in this slide.

Access Network from the nodes of backbone network to the customers exists with the media as optical fiber, copper cable and radio systems. The interfaces are mainly traditional voice-level or 64kbps- and E1-based connections.

Customer Network is composed various CPE (Customer Premise Equipment), corresponding to the services provided, such as telephone, fax and computers by mainly dedicated lines for each.

A key point of the existing networks is that they have been based on the well proven interfaces defined by telecom experts, namely ITU. On the other hand, they are nowadays considered rigid and the lack of flexibility to the new comer, Internet.



1.6 Basic Configuration of IP-based Networks

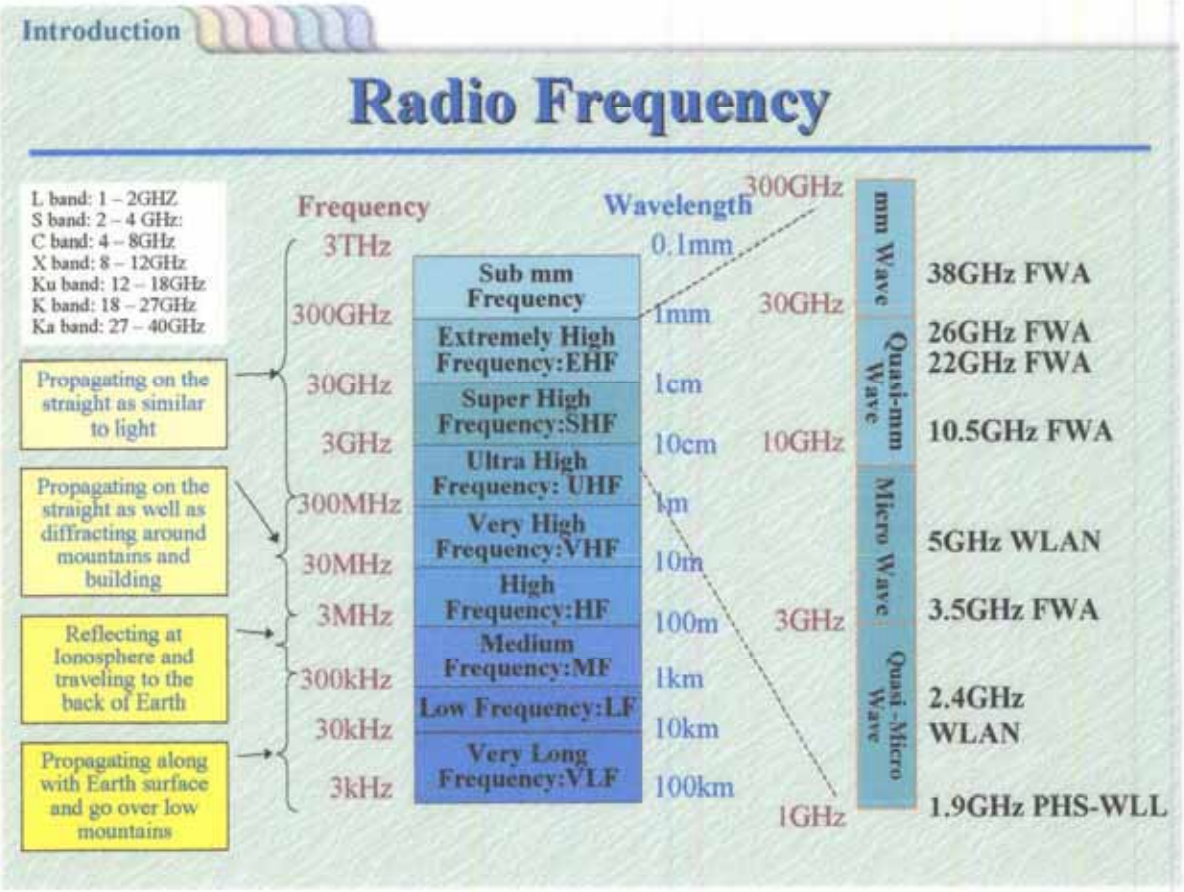
The existing network depicted in the previous chart will be superseded with the IP-based network as shown here.

In the backbone network, IP SW Router will take the place of Data (or Telephone) Exchange. The current transmission terminals such as PDH/SDH, ATM and so on will be eventually replaced with the high-speed Ethernet (e.g. 10Gbit Ethernet or higher) terminals.

The access networks are drastically changing, too. The legacy copper cable is now loaded with heavy data streams on top of voice for the IP Access Service as xDSL. The CATV cable is carrying the IP traffic and connected to the telecom carrier networks through the Internet. The most promising broadband medium, FTTH (Fiber To The Home), is nowadays considered to be able to provide the IP Access Service even to SOHO/Consumer-level users with reasonable service charge. As our theme here is Wireless IP Access, the chart shows the broadband FWA (Fixed Wireless Access) having the interface of 10/100 Base-T.

In the customer networks, the LAN connection is now ordinary in most of offices, in parallel with the telephone networks with PBX. Everyone realize that the twofold networks are annoyance and hope that if the book value of traditional telephone equipment decreases, they should be converged on the LAN with VoIP technology.

For the customer IP wireless networks, the wireless LAN becomes popular and other new comers such as Bluetooth, HomeRF and UWB will be emerged soon.



1.7 Radio Frequency

For the basic understanding of utilization of radio waves, one important issue, 'Radio Frequency', is explained.

The overall picture of radio wave is as shown here. As the system tends to be broadband, higher radio frequencies are applied to hold wideband.

Band (GHz)	Lower Frequency (MHz)	Upper Frequency (MHz)	P to P System	P to MP System
3.5	3,400	3,600	✓	✓
L6	5,925	6,425	✓	
U6	6,425	7,100	✓	
7	7,125	7,900	✓	
8	8,200	8,500	✓	
10	10,150	10,680	✓	✓
11	10,700	11,700	✓	
13	12,750	13,250	✓	
15	14,500	15,350	✓	
18	17,700	19,700	✓	
23	21,200	23,600	✓	
26	24,500	26,500	✓	✓
38	37,000	39,500	✓	✓

Microwave including Quasi-Microwave, Quasi-mm wave are the most cultivated radio waves for broadband application. Among them, there is a clear distinction between 'below 10GHz' and 'above 10GHz', from the propagation performance characteristics point of view.

The degradation due to the multi-path fading, caused mainly by refraction in the air, is dominant for 'below 10GHz' and the rain attenuation is dominant for 'above 10GHz'. The Quasi-Microwave has the nature of diffraction, with which the non line-of-sight systems are feasible.

This table shows the RF allocation for the Fixed Services.