

Telecom Services

— Applications, Architectures, and Technologies

Dr. Suresh Borkar
Telek Solutions and IIT, Chicago
borkar@iit.edu

IEEE, Pune
Jul 31, 2010

Telecom Services

- **Current and Upcoming Telecom Services**
- **Services Implications and Architecture**
- **Telecom Networks and Systems**
- **Illustrative Examples**
 - **Voice over Internet Protocol (VoIP)**
 - **Internet Protocol TeleVision (IPTV)**
 - **Cloud Computing**
- **Applicability to India**
- **Concluding Remarks**

Telecom Services

- **Current and Upcoming Telecom Services**
- **Services Implications and Architecture**
- **Telecom Networks and Systems**
- **Illustrative Examples**
 - VoIP
 - IPTV
 - Cloud Computing
- **Applicability to India**
- **Concluding Remarks**

Services Continuum

- **Basic Voice Communications and Low Speed Data**
- **Advanced Communications and Broadband**
- **Universal and Affordable Mobile Broadband**
- **User Managed Multi Media Mobile Applications**

Basic Voice Communications and Low Speed Data

- **Classic Carrier Grade Voice**
 - **Supplementary Services**
- **Mobile Voice Communications**
- **Low Speed Data Services**
 - **Fax**
 - **Short Message Services / Text**

Advanced Communications and Broadband

- **Triple Play**
 - **Voice, Video, and Data Bundle**
 - **Primarily Landline**
- **E-Anything**
 - **Banking and Commerce**
 - **Government Services**
 - **Distance Education**
 - **Health Services**
 - **Operations Support, Call Centers, Simultaneous Web and Voice Support**
 - **Entertainment**
 - **Social and Professional Networking**
- **Voice over IP (VoIP) Introduction**

Universal and Affordable Mobile Broadband

- **Quadruple Play**
 - **Voice, Data, Video, Mobile Multimedia**
 - **Bandwidth Intensive, Rich Media Applications**
- **Voice Over Anything Introduction**
- **Access to Content and Services from any Location, with Any Device, at Any Time**
 - **Parity with Wired Web**
- **Mobile E-Anything Access**
- **User Generated Applications**
- **Gaming**
- **Location Awareness Services**
 - **Interactive Navigation, Community Services**
- **Advanced Security Services**

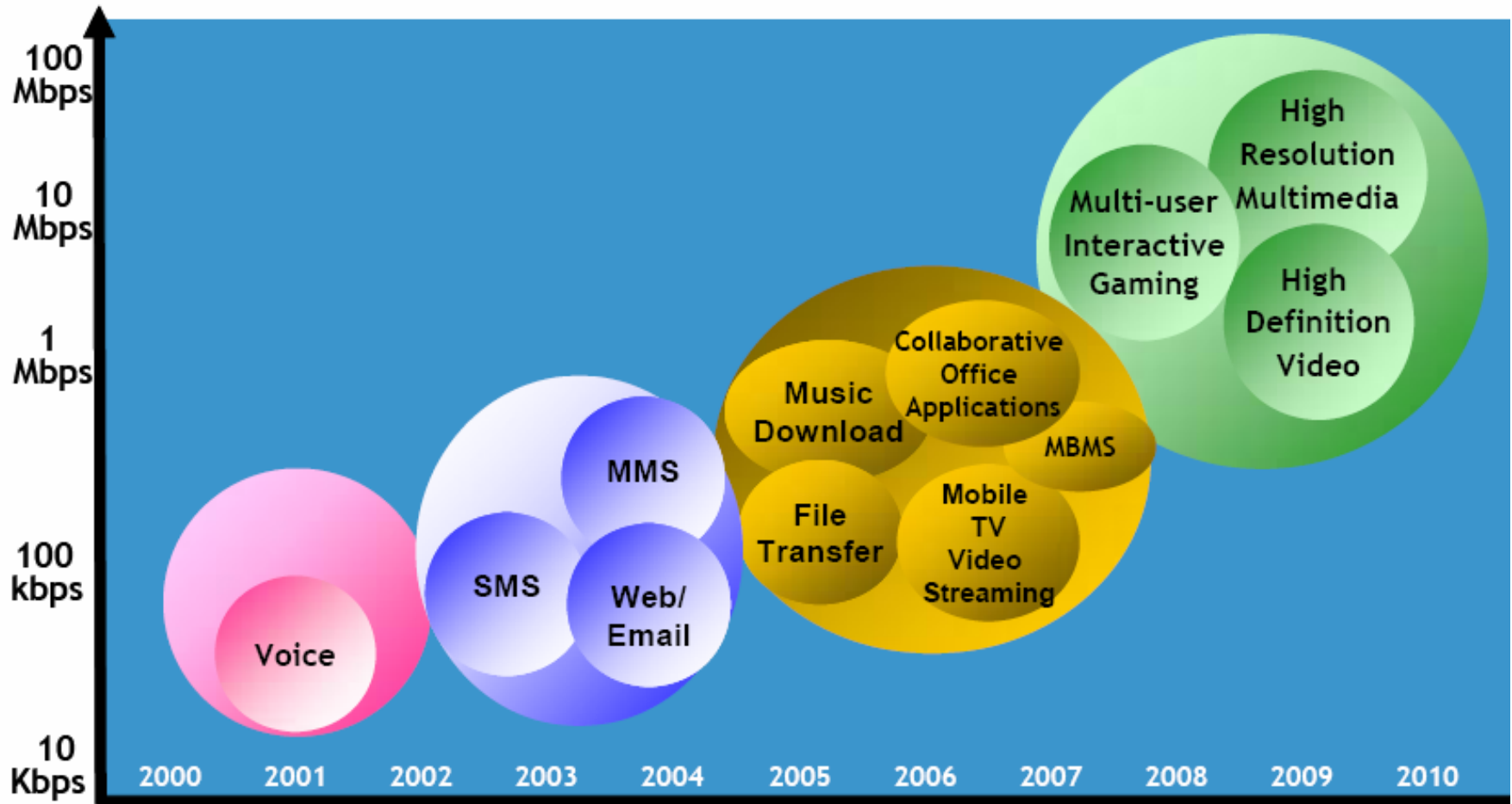
User Managed Multi Media Mobile Applications

- **Mobile E-Anything Control and Real Time Response**
- **Unified Communications with Multi Media Creation and Sharing**
- **Multi-Tasking**
 - **Combinations of Streaming Video, Emails, Instant Messaging (IM), Web Browsing, Social Networking**
- **Cloud Telephony**
- **Entertainment Flexibility**
 - **View More Content on Their Own Schedules**
 - **Time-shifted TV, Video On Demand (VOD), and Digital Video Recording**
 - **Internet Protocol TV (IPTV)**
 - **Movies on Demand**
 - **Integrated Voice over-IP**

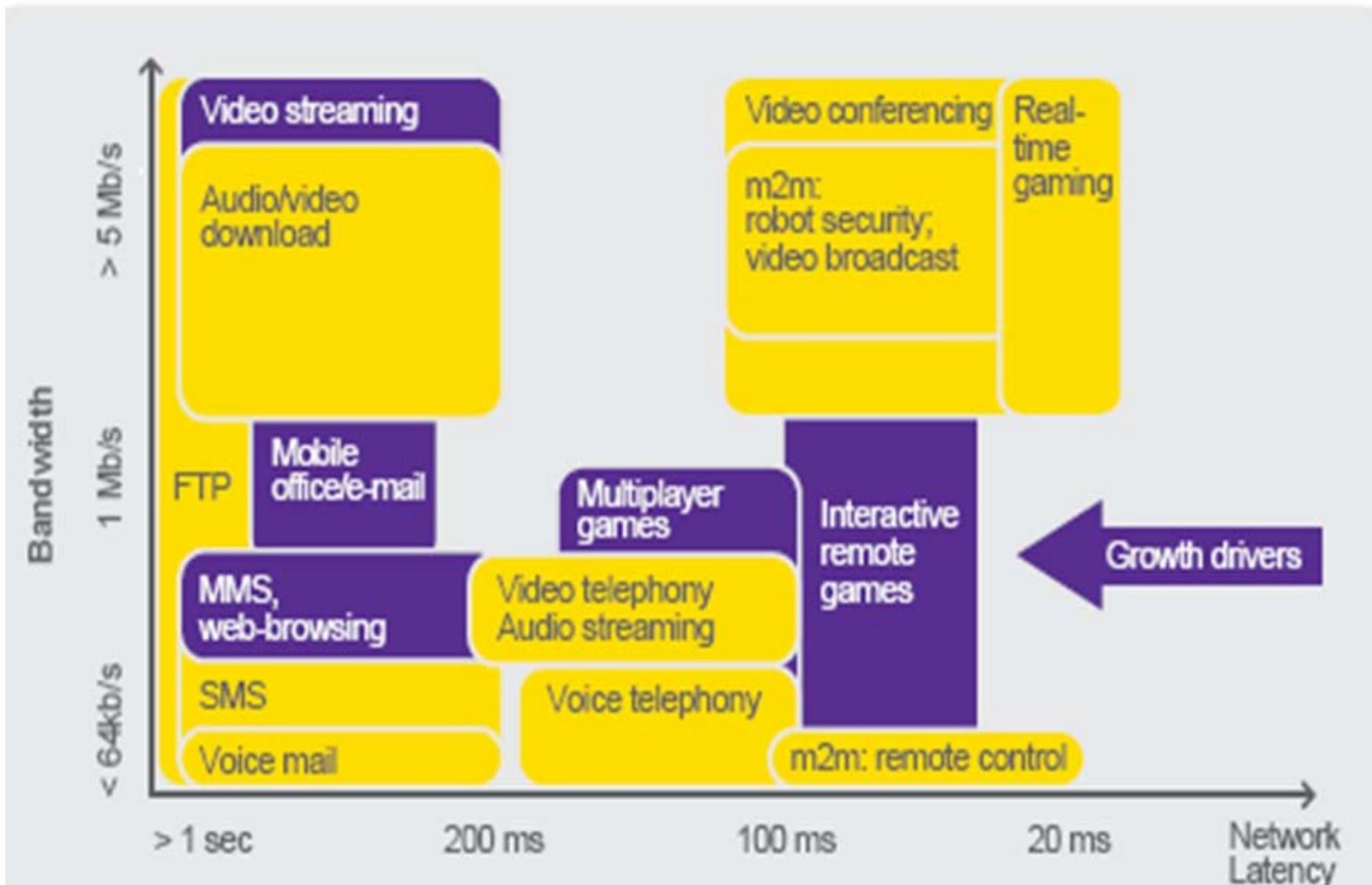
Telecom Services

- Current and Upcoming Telecom Services
- **Services Implications and Architecture**
- Telecom Networks and Systems
- Illustrative Examples
 - VoIP
 - IPTV
 - Cloud Computing
- Applicability to India
- Concluding Remarks

Multi Media Services Bandwidth



Bandwidth and Latency



Multi Media Applications Attributes

Quality of Service (QoS)

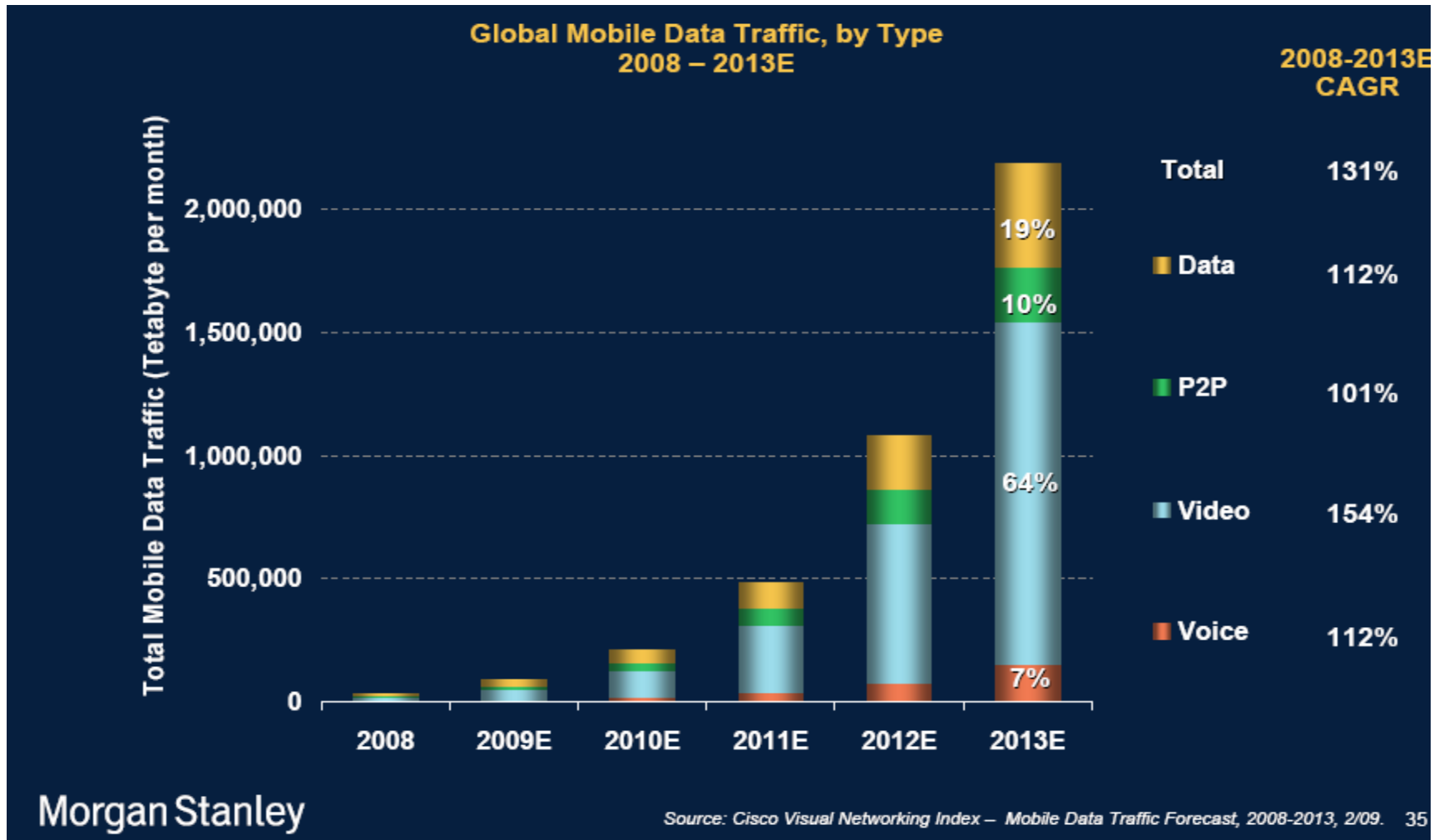
Class	Application	Bit Error Rate	Bandwidth Guideline		Latency Guideline		Jitter Guideline	
1.	Multiplayer Interactive Gaming	Med 10^{-6}	Low to V High	50 Kbps to 5 Mbps	Very Low	< 25 msec	V Low 10 ms	
2.	VoIP & Video Conference	Moderate 10^{-5}	Low to High	32 Kbps to 2 Mbps	Low	< 160 msec	Low	< 50 msec
3.	Streaming Media	Med 10^{-6}	Moderate	5 kbps to 1 Mbps	N/A		Moderate	< 100 msec
4.	Web Browsing & Instant Messaging	Low 10^{-7}	Low to V High	50 kbps to 5 Mbps	N/A		Moderate < 100 ms	
5.	Media Content Downloads	Very Low 10^{-8}	V High	> 10 Mbps	N/A		V Low 10 ms	

Advanced Services Implications

- **Fixed-Mobile-Convergence with Unified Voice, Data, and Video Applications on a Single Mobile Handset**
 - Stationary (Home Zone) → Nomadic → Mobility
- **Significant Increase in the Amount of Bandwidth due to Multitasking and Packing More Media Consumption into Smaller Slices of Time**
 - Storage, Transmission, and Processing
 - 18 Mbps per Person per Device (Near Future)
 - 1GB of Data in a Single Workday Downloading and Sending Emails for Business Users
 - 2GB is Roughly Equal to a Single Digital, IP Movie
 - Peer-to-Peer Broadband Connectivity
- **Information Technology (IT) and Telecom Services Mergers**
 - IT
 - Rich Content, Data Applications, and Business
 - Telecom
 - Intelligent, Real-Time, “In-the-Network” Functions
- **Information Assurance and Security**
 - Authentication, Confidentiality, Integrity
- **High Degree of User Control, Personalization, and Content Generation**

Mobile Data Traffic Driven by Video

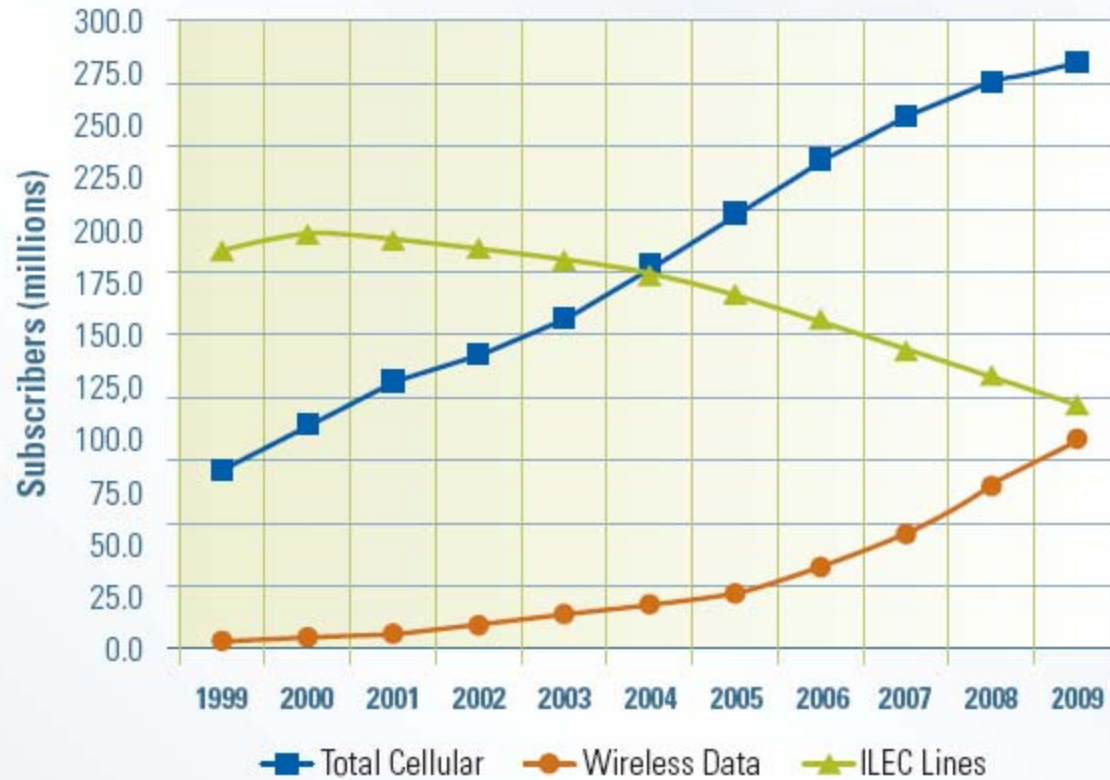
Voice → Data → Video



Handling of Video, Transmission of Packet Data

Wired to Wireless Users (US)

■ 600M



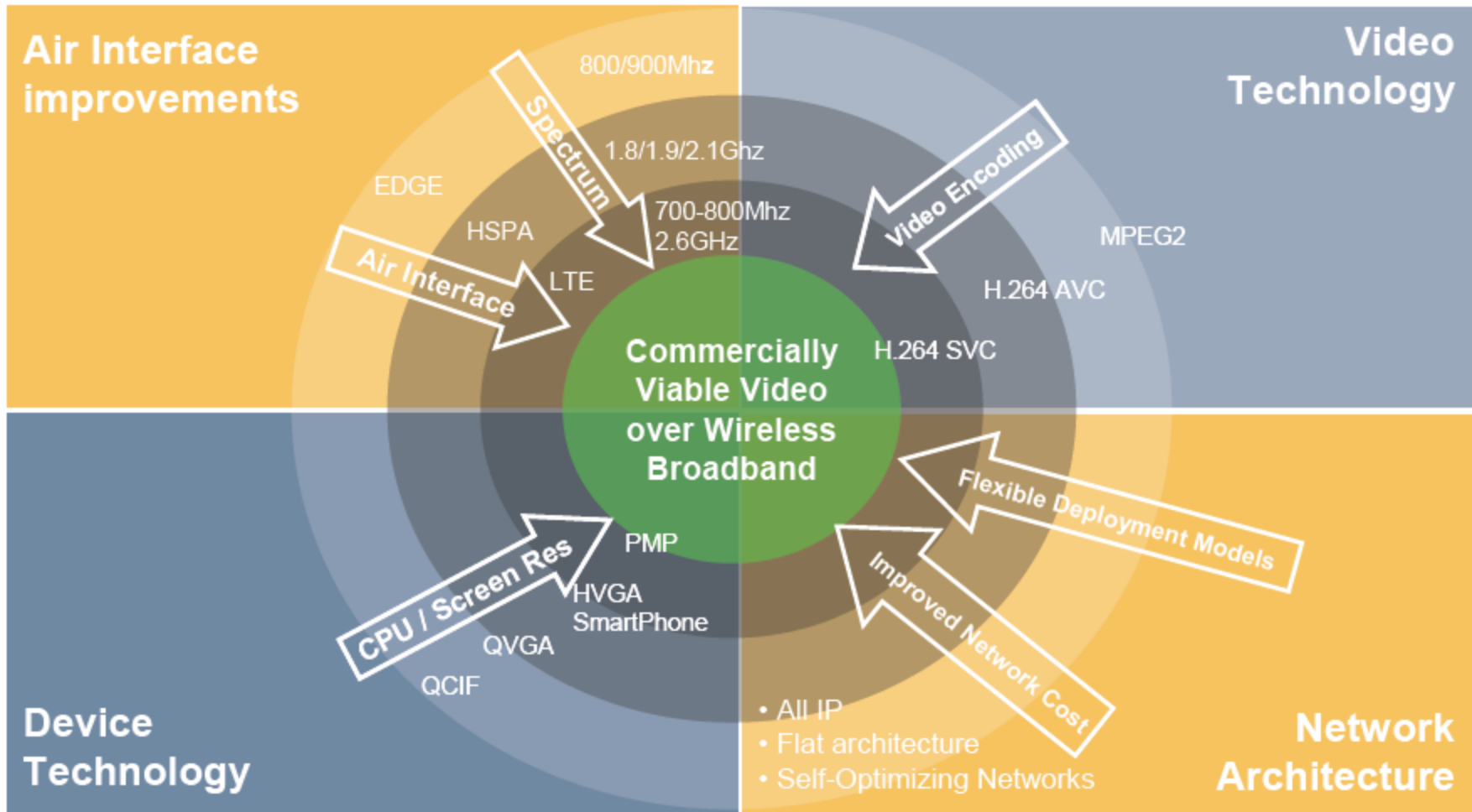
Source: CTIA; FCC; Skyline est.

▲ 35M
● 0M

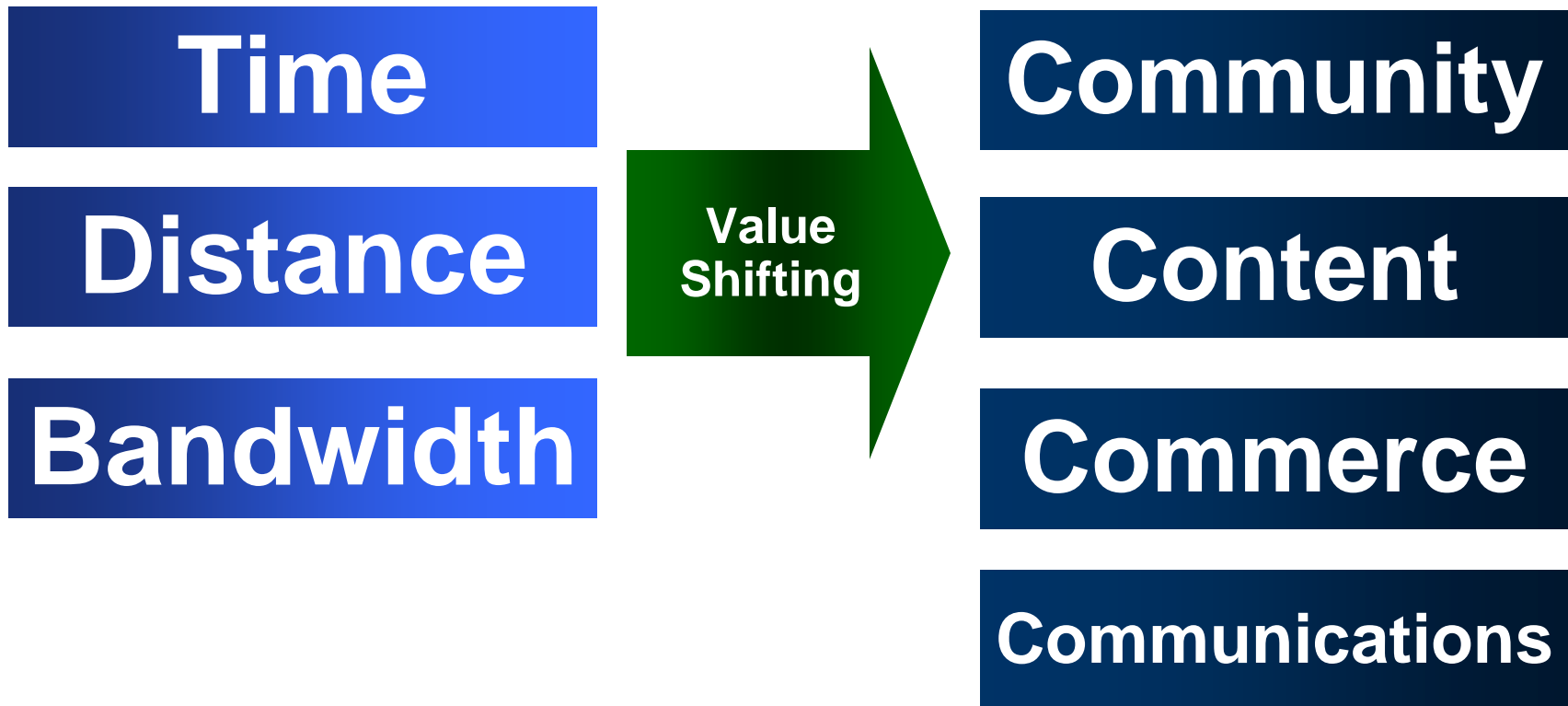
India

Similar Trends in India – Different Scales and Timeline

Convergence of Technologies for Improved Video



Shifting Value of Communications and Computing



Mainframes 1960's, MiniComputing 1970's, Personal Computing 1980's,
Desktop Internet 1990's, Mobile Internet 2000's

Interactive Mobile Broadband Architecture

- **Digital, Converged, Mobile IP World**
 - **Broadband Access Anytime Anywhere**
 - **Network Applications-Aware**
 - **Quality of Service (QoS)**
 - **Layered, Hierarchical**
 - **User Equipment (UE), Access, Core, Applications**
- **Multiple Media Streams on Multiple Devices**
- **User Devices**
 - **Personalization, Control, Content Generation and Sharing, Seamless Access Independent of Networks**
 - **XML, JAVA**
- **Access**
 - **Allow Device Agnostic Services**
 - **Wireless**
 - **Asymmetrical (Higher Downlink) to Symmetrical**
- **All-IP Networks**
 - **Migration from "Deterministic" Circuit Switched Networks to "Statistical" Packet Networks**
 - **Allow Access-Agnostic Service Provisioning and Operations**
 - **End to End Quality of Service (QoS)**
- **Unicast/Multicast/Broadcast Capability**
 - **User Customized**

Telecom Services

- Current and Upcoming Telecom Services
- Applications, Attributes, and Implications
- **Telecom Networks and Systems**
- Illustrative Examples
 - VoIP
 - IPTV
 - Cloud Computing
- Applicability to India
- Concluding Remarks

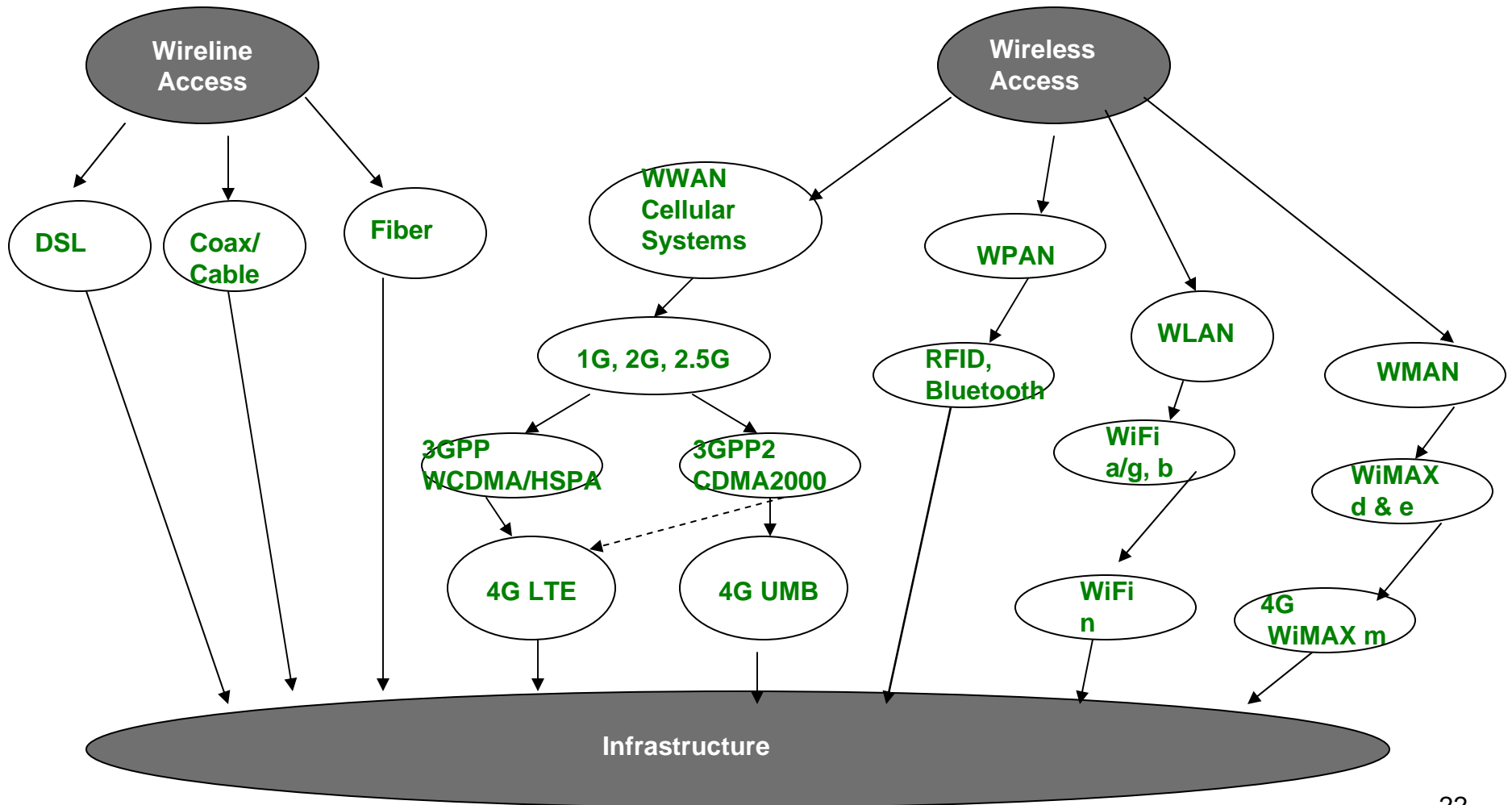
User Devices and Systems

- **Smart Mobile Phones**
 - 10Mbps+ Bandwidth
 - Application Protocol Interfaces / Operating Systems
 - User Generated Content
 - Migrating to Interactive and Peer-to-Peer Capabilities
- **User Equipment (UE) Devices**
 - mp3 Players, Portable Media Players, Digital Cameras, Game Consoles, Smart Phones, Media Adapters, PCs, Flat-Screen TVs, Home Theater Systems, Digital Video Recorders (DVRs), HD-DVD Players
- **Mobile Access to Business, Entertainment, and Government Services**

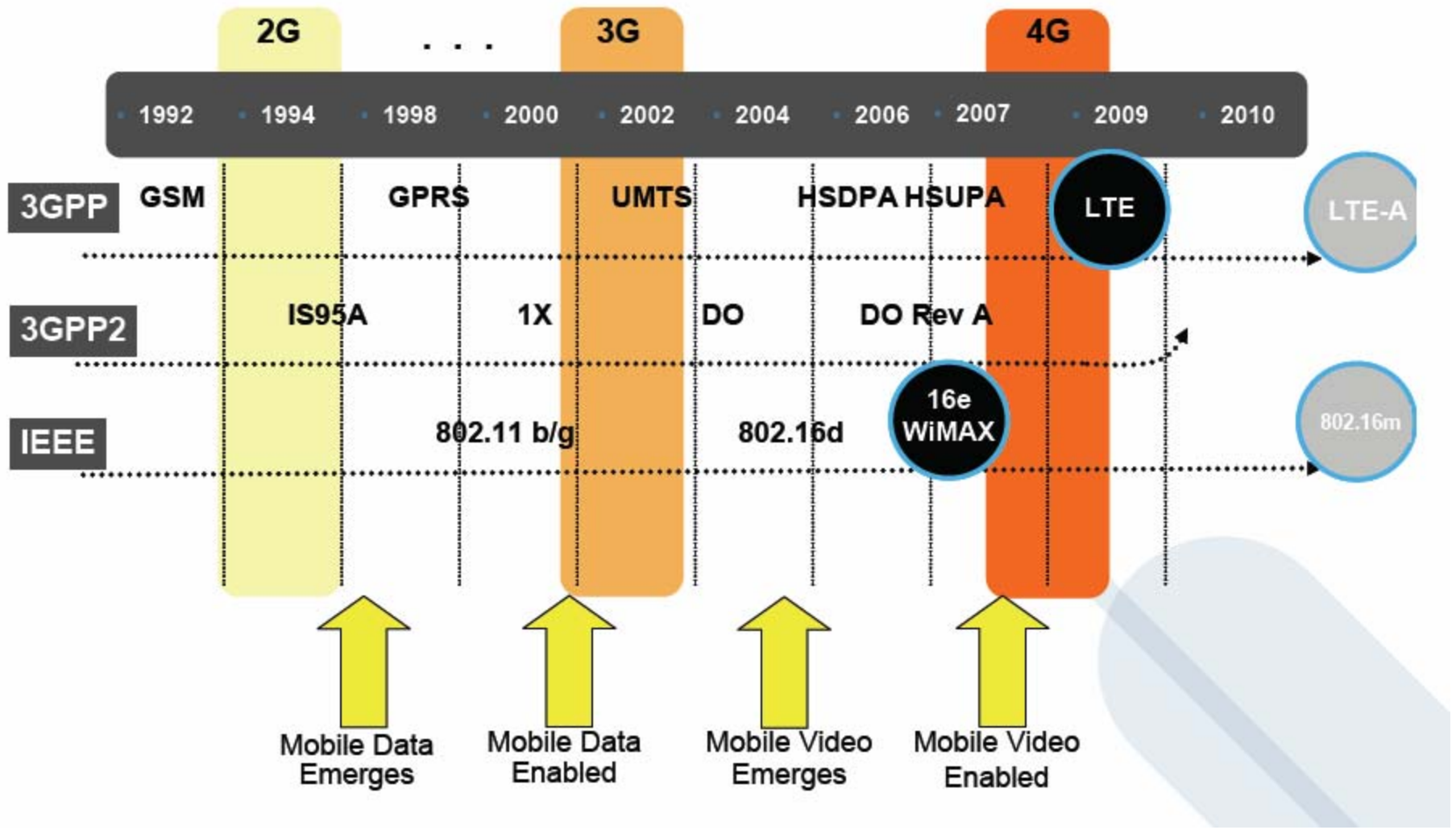
Access Network

- **Wireline and Wireless**
 - Radio Access Networks
 - Basic Voice Access (Few Kbps) to 100's of Mbps
- **Wireless Geographic Coverage**
 - Proximity Area Network (PAN), Local Area Network (WLAN), Wireless Metropolitan Area Network (WMAN), Wireless Wide Area Network (WWAN)
 - Macro Cells, Micro Cells, and Femto Cells
- **Bringing IP to the User Devices**
- **Asymmetrical and Symmetrical Bandwidths Allocation Depending upon Class of Application**
- **Connections to Best Available Network and Seamless Roaming**

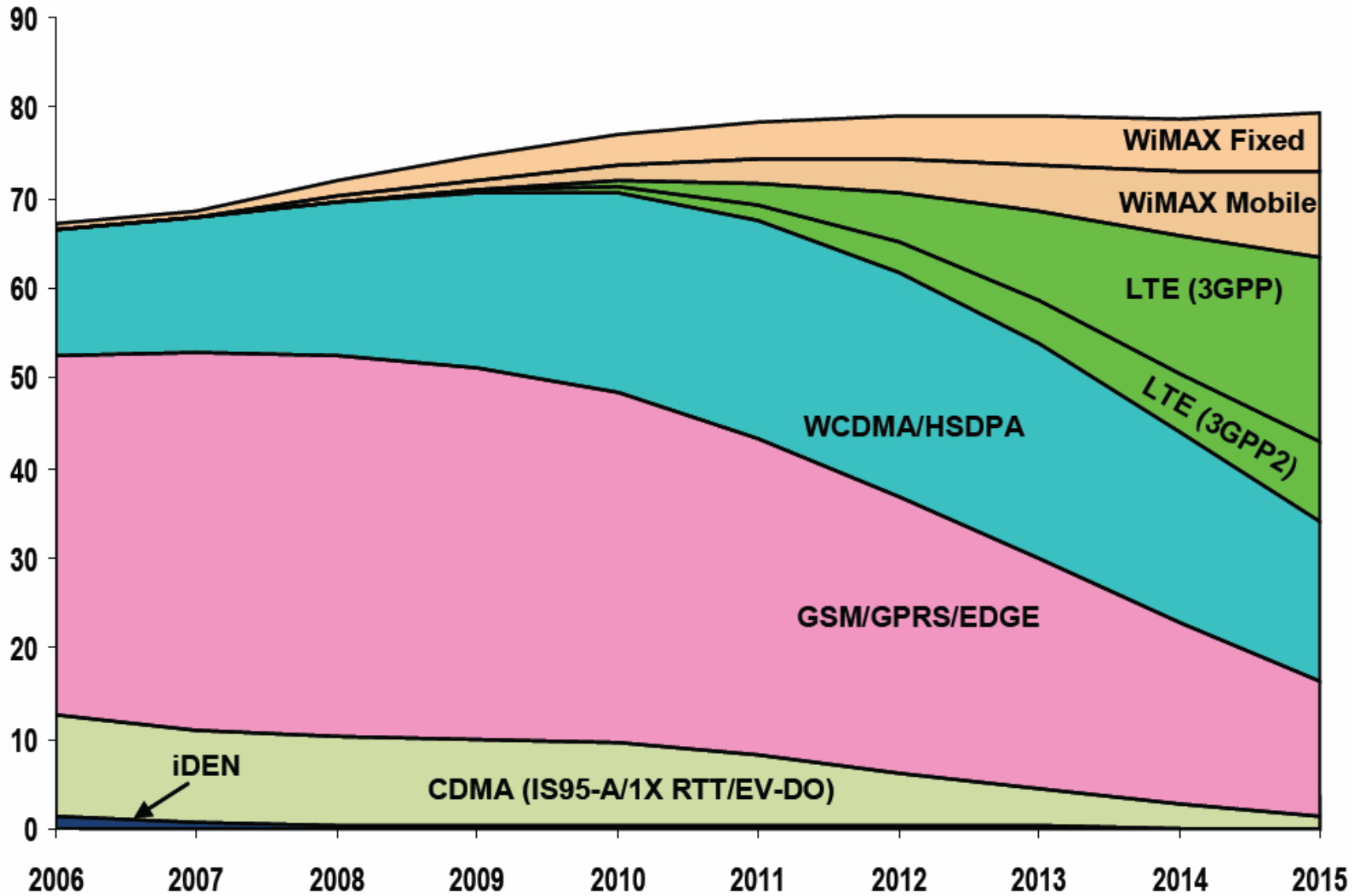
Wireline and Wireless Access



Commercial Wireless Broadband Standards



Wireless Technology Forecast



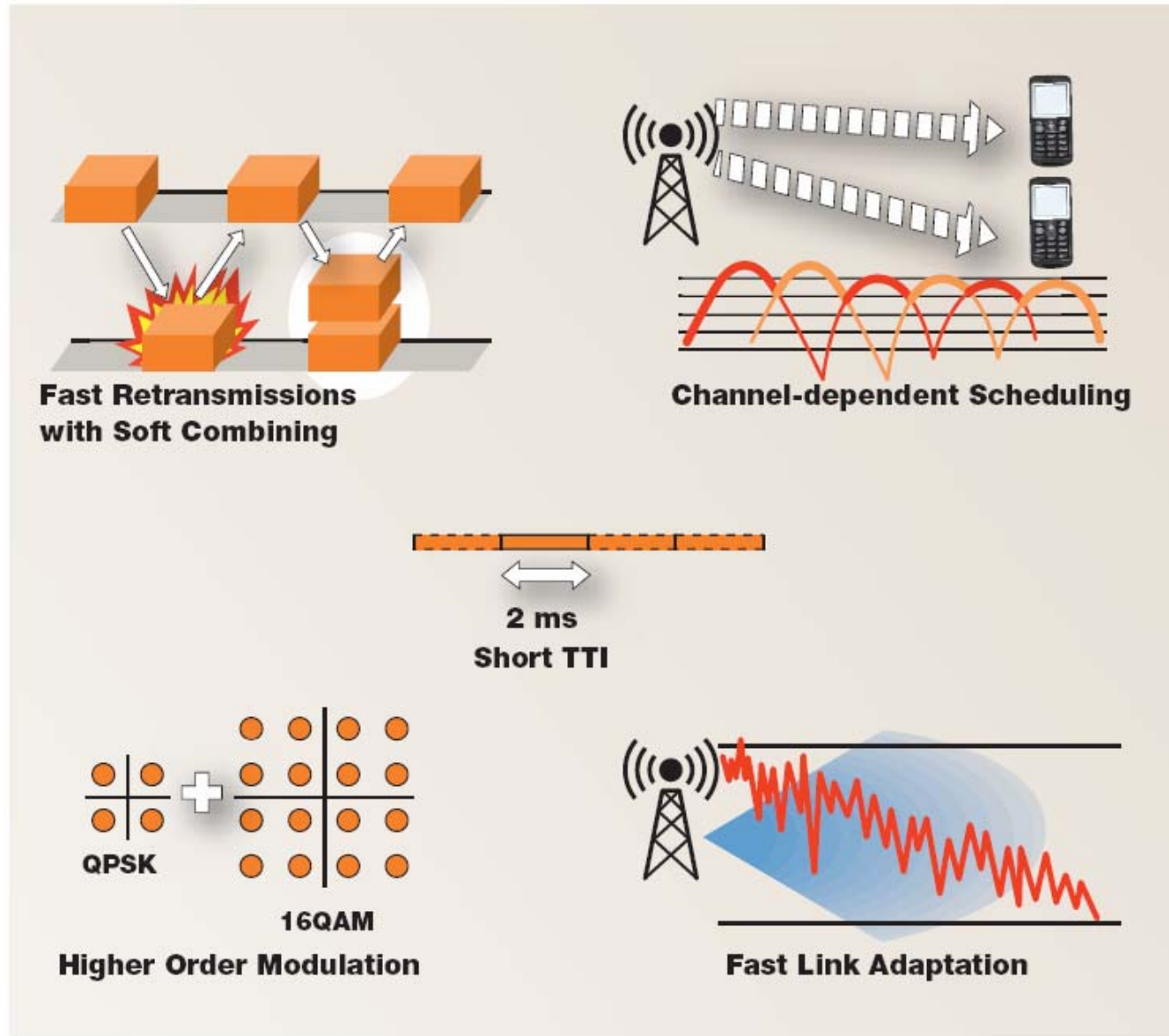
Radio Techniques for Mobile Broadband - 1

- **Higher Data Rates (and Capacity)**
 - Higher-Order Modulation Schemes (e.g.16QAM and 64QAM)
 - Multiple-Input Multiple-Output (MIMO) Advanced Antenna Systems
- **Greater Coverage**
 - Advanced Antenna Systems and Receivers
 - Enhance the Radio Link and Improve Cell Range
- **Improved QoS and Low Latency**
 - Dynamic Scheduling
 - End-User Traffic Streams Prioritized According to Service Level Agreements (SLAs)
 - Short Transmission Time Interval (TTI)

Radio Techniques for Mobile Broadband - 2

- **Higher Capacity**
 - **Shared-Channel Transmission**
 - **Efficient Use of Available Time/Frequency/Codes and Power Resources**
 - **Link Adaptation**
 - **Dynamically Optimize Transmission Parameters Depending on Actual Radio Conditions**
 - **Channel-Dependent Scheduling**
 - **Assign Radio Resources to Users with the Most Favorable Radio Conditions**
 - **Hybrid Automatic Repeat Request (HARQ)**
 - **Enable Rapid Retransmission of Missing Data**
 - **Soft-Combining**
 - **Significantly Improve Performance and Robustness**

Key Techniques in Wireless Communications



Core Networks

- **Legacy Public Switched Telephone Networks (PSTN)**
 - **Deterministic, Focused on Voice**
- **Packetized Networks**
 - **Change the Nature of the Underlying Delivery Infrastructure for ALL Traffic**
 - **Internet Protocol (IP)**
 - **Statistical Traffic Models**
 - **Support Multimedia Applications**
 - **Management of Several Real Time and Non-Real Time Sessions Simultaneously**
 - **Quality of Service (QoS) Management**
 - **Manage Packet Loss, Jitter, and Delay Corresponding to the Applications**
 - **Rely on Internet Engineering Task Force (IETF) Protocols**

Internet Engineering Task Force (IETF) Key Protocols

- **Routing**
 - IPv4 and IPv6
 - Larger Address Space, Performance Improvements
 - Transmission Control Protocol (TCP)/ User Datagram Protocol (UDP)
 - MPLS for Layer 2 Independent Routing
- **Signaling**
 - Sessions Initiation Protocol (SIP)
 - Setup and Manage a Session
 - Session Description Protocol (SDP)
 - Describe Multimedia Sessions
- **Quality of Service (QoS)**
 - Integrated Services (Int-Serv) and Differentiated Services (Diff-Serv)
- **Security**
 - IPSec
- **Subscriber Management and Billing**
 - Accounting, Authentication and Authorization (AAA) Server
 - Remote Authentication Dial In User Service (RADIUS) and DIAMETER

Other Service Related Network Issues

- **Mesh Networks**
- **Inter-Technology Mobility**
 - **Multi Mode Devices**
 - **Inter Technology Standards and Agreements**
- **Inter Technology with Legacy Networks**
 - **Fall back, Migration, and Co-existence of services, e.g., Voice**
- **Spectrum Allocation and Operations**
- **Managed Operations and Services of Disparate Networks**
 - **Self Optimized Networks (SONs)**
- **Content Based Billing**

Telecom Services

- **Current and Upcoming Telecom Services**
- **Applications, Attributes, and Implications**
- **Telecom Networks and Systems**
- **Illustrative Examples**
 - **VoIP**
 - **IPTV**
 - **Cloud Computing**
- **Applicability to India**
- **Concluding Remarks**

VoIP

- **A Member of a Family of Real-Time Conversational Communications Applications**
 - End-to-end Quality-of-Service (QoS) Versus Simply a 'Best-Effort' Application
 - Part of Transition to a Converged, Fully Multimedia-Enabled, Real Time Packet Based Communication Infrastructure
 - VoWiFi, VoWiMAX, VoLTE
- **Services**
 - Web-Based Services
 - Consumer Services
 - Location Based
 - Mobility
- **PSTN Parity Issues**
 - Voice Quality, Services and Types of end user terminals, Quality of Service (QoS), Security, Regulatory, Operations and Management, Reliability/Availability

VoIP Enabling Technologies

- **Computing Power for Real-Time Multimedia**
 - Moore's Law
- **Voice Processing Technology**
 - Digital Signal Processing (DSP)
 - Reducing the Inefficiencies Due to Packet Overheads Inherent Within a VoIP System
- **Advent of Affordable, Ubiquitous Computing and Broadband Transport**
 - Integral multimedia support in the form of personal computers
 - Computing Infrastructure for Audio and Video Capabilities
 - Data Networking in the Form of IP
- **Direct integration of VoIP Gateways Within Access Router Hardware**

Typical Architecture

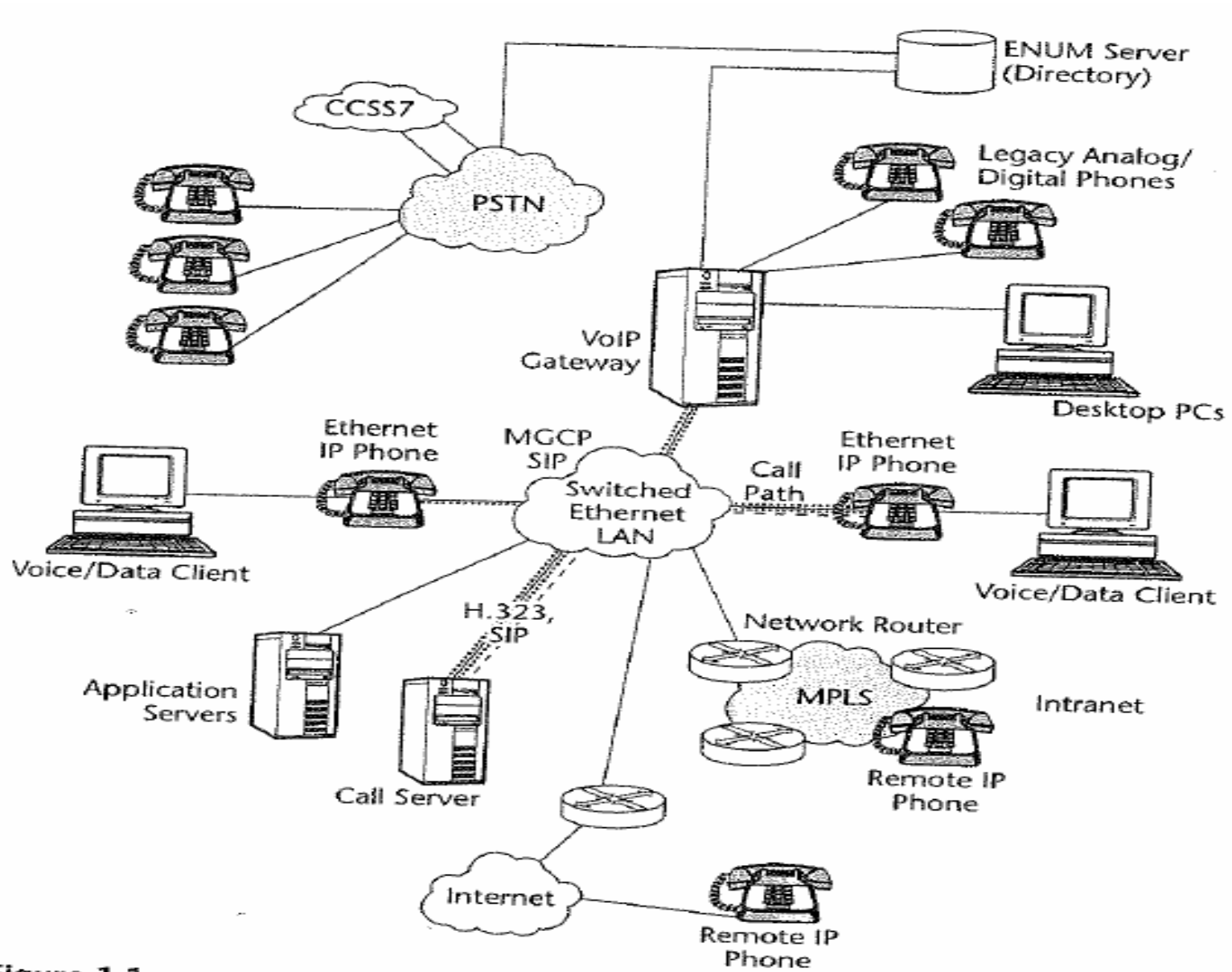
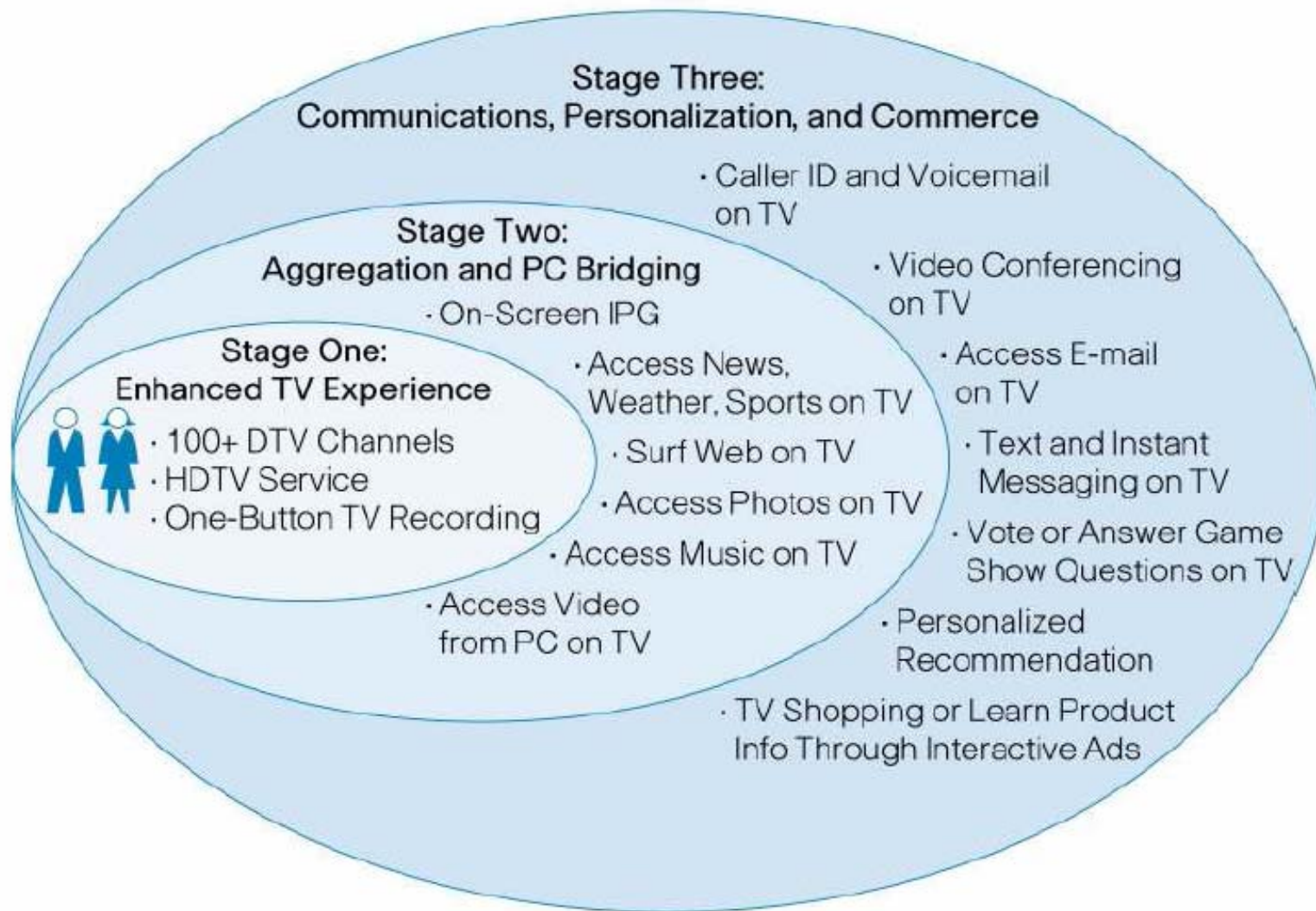


Figure 1.5
Telecom Services ver1

IPTV

- **Part of Multimedia Applications**
 - **Television/Video/ Audio/Text/Graphics/Data Delivered over IP Based Networks**
 - **Connected, Interactive, and Personalized**
 - **Parity with Control Capabilities as Standard TVs and Recorders**
- **Internet Video**
 - **Watch Videos, Movie Previews, and Web-Cams**
- **IPTV with Video Telephony**
 - **VoD (Video on Demand), PVR (Personal Video Recorders), and EPG (Electronic Program Guide)**
 - **Conferencing, Presence, and Instant Messaging (IM)**
 - **E-Anything**

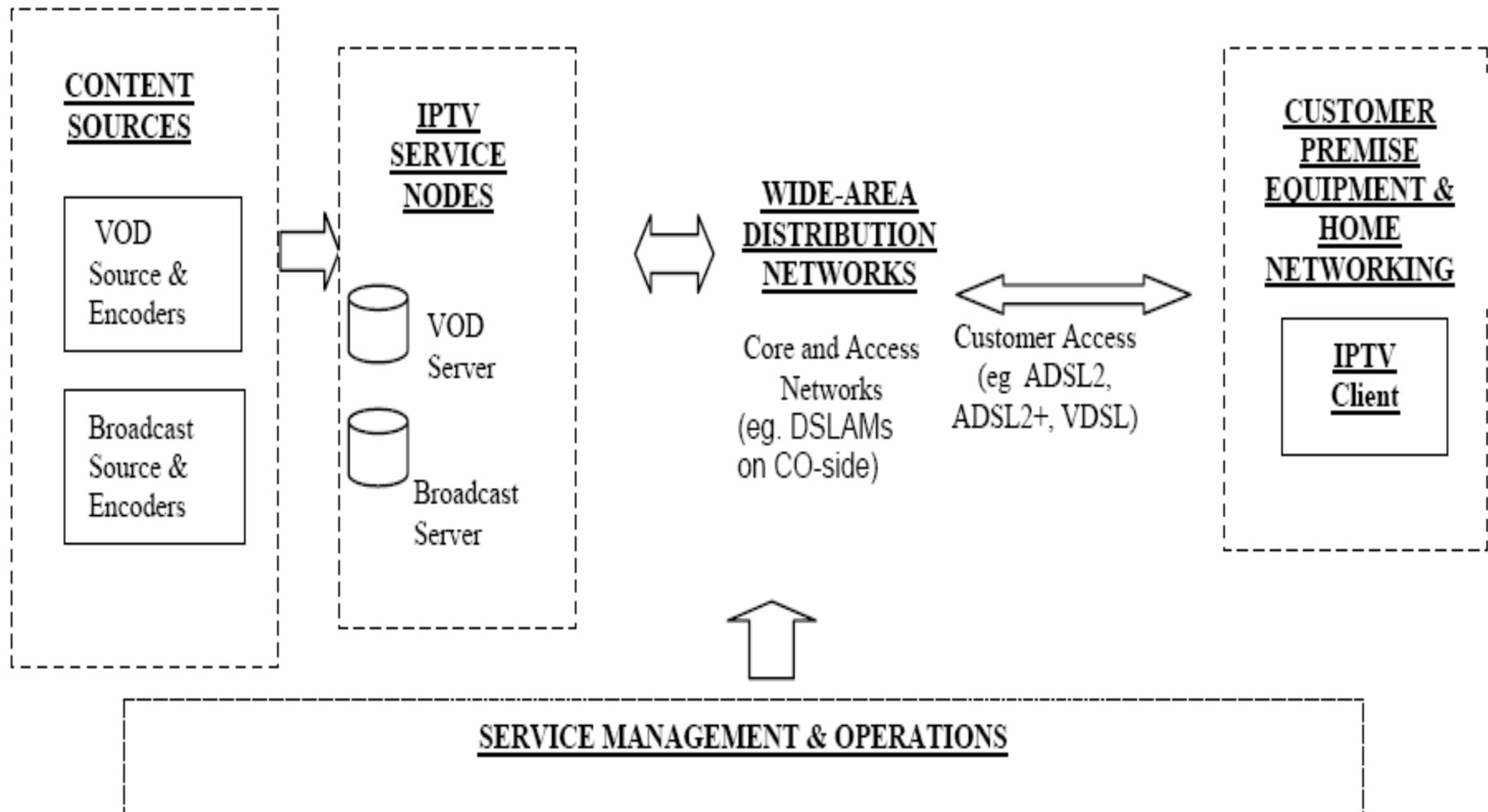
IPTV Service Evolution



Enabling Technologies

- **Compression**
 - One HDTV format produces > 5300 GB per hour of uncompressed digital signal
- **Quality of Service (QoS)**
 - IETF Integrated Services (Intserv) and Differentiated Services (Diffserv) Protocols
- **Control Traffic Management Real Time Response**
 - Stringent Response to User Commands
- **User Traffic Management**
 - Multicasting and Unicasting
 - Time Deferred Data Presentation
- **Key Constituents**
 - Broadband Access
 - Digital TV
 - IP Network
 - Customer Premise Equipment
 - Service / Content Provider Equipment

Generic IPTV System Architecture



Ref: [\[\[INTE\] Intellon, White Paper, IPTV, 2005](#)

Cloud Computing



- **Access Internet Services Over Lightweight Portable Devices**
- **Rely on Computing and Data in Large Service Centers**
 - **Infrastructure as a Service (IaaS)**
- **Technological Needs**
 - **Virtualization, Service Oriented Software, Grid Computing Technologies, Management of Large Facilities, and Power Efficiency**
- **Cloud Architecture Layers**
 - **Infrastructure**
 - **Basic Storage and Compute Capabilities**
 - **Platform**
 - **Develop, Test, Deploy, Host, and Maintain Applications**
 - **Application**
 - **Applications offered to the customer**

Tussle Between Distributed and Centralized Service Architectures

Cloud Computing Issues

- **Software / Hardware Architecture**
 - High degree of Parallelism and Multi Threading
 - Storage in Solid State Drives (SDDs)
- **Data Management**
 - Data Replicated Across Large Geographic Distances
 - Analytical Data Management Tasks, Multi Tenant Databases
- **Cloud**
 - Use of Same Artifacts, e.g. Management Tools, Virtual Server Images with Different Providers and Platforms
- **Security and Privacy**
 - Protecting “Outsourced” Data
- **Service Provisioning and Cloud Economics**
 - Complexities of Service Level Agreements (SLAs)

Telecom Services

- **Current and Upcoming Telecom Services**
- **Applications, Attributes, and Implications**
- **Telecom Networks and Systems**
- **Illustrative Examples**
 - VoIP
 - IPTV
 - Cloud Computing
- **Applicability to India**
- **Concluding Remarks**

India Telecom Services Scene

▪ Current Scene

- Limited “Broadband” Penetration (DSL)
- Basic Mobile 2G Wireless Voice
- Extensive Intra-City and Urban/Rural Gaps and Digital Divide

▪ Affordability

- Low Mean and Huge Skewness
- Extremely Uneven / Lopsided Wealth Distribution
 - 10% “owns” 60% of Wealth
 - 35% of Population Below Poverty Line
- Rs 1K/Year (2.5% of Per Capita Income)

▪ Estimated (Minimal) Cost of Mobile Broadband Per Subscriber

- Rs. 10K/Year (Spectrum, Deployment, Operations and Management)

Living in All Centuries at the Same Time

India Telecom Service Key Needs

- **Multi-Tiered Broadband Telecom a Critical Infrastructure Investment**
- **Services Consistent and Relevant with India's Needs**
 - **Productivity, Mass Education, Market Access**
- **“Community” Based Service Availability**
 - **Urban and Rural Coverage**
 - **Cyber Cafes and Kiosks**
 - **Subsidized Smart Phones**
- **Leapfrogging Technology**
 - **3G and 4G Wireless Access**
 - **WCDMA/HSPA, WiMAX, LTE**
 - **Advanced Smart User Equipment (UE)**
 - **Hotspot Coverage Using WiFi, Femtocells**
 - **Wireless Backhaul (e.g., WiMAX)**
 - **Packet Switched Networks**
- **Consolidation of Service Providers**

Telecom Services

- Current and Upcoming Telecom Services
- Applications, Attributes, and Implications
- Telecom Networks and Systems
- Illustrative Examples
 - VoIP
 - IPTV
 - Cloud Computing
- Applicability to India
- **Concluding Remarks**

Concluding Remarks

▪ Service Continuum

- Basic Voice Communications and Low Speed Data**
- Advanced Communications and Broadband**
- Universal and Affordable Mobile Broadband**
- User Managed Multi Media Mobile Applications**

▪ Technology Evolution

- Copper, Cable, Fiber Wireline Access**
- WLAN, WMAN, and Cellular WWAN Wireless Access**
 - 2G, 3G, 4G**
- Packet Core**

▪ India Telecom

- Significant Mobile Voice and Limited Wireline Penetration**
 - Limited Applicability of Wireline Access**
- Services Relevant to India's Needs**
- Concrete Steps to Alleviate Affordability Gaps**
- Focus on 3G and 4G Wireless Broadband Access, Packetized Core, and Wireless Backhaul**