Wireless Access

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International Telecommunication Union

FIXED WIRELESS ACCESS

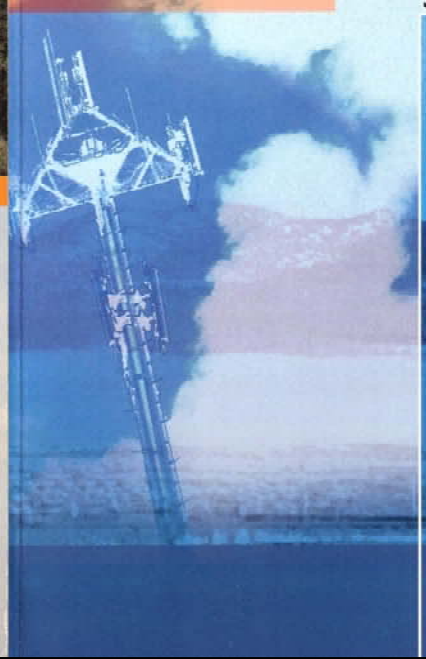
Handbook on Land Mobile (including Wireless Access)

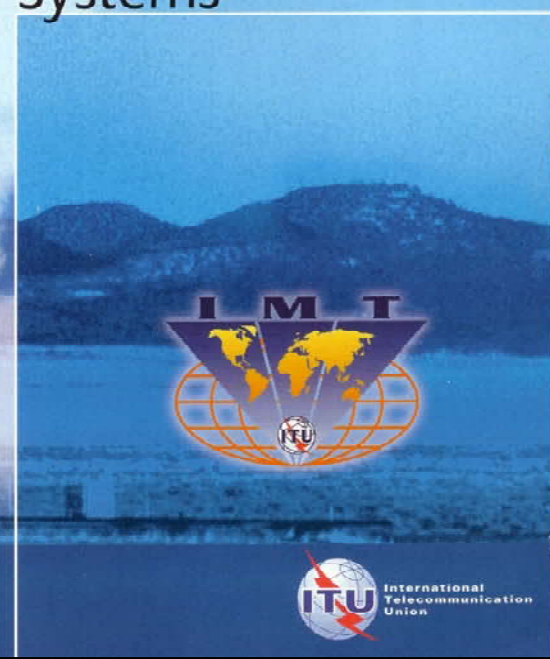
Volume 1
2nd Edition

Radiocommunication Bureau

International Telecommunication Union

Deployment of IMT-2000 Systems





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Outline

- Definition of wireless access and types of wireless access
- The origins of Fixed Wireless Access (FWA)
- Broadband Wireless Access (BWA)
- Radio Local Area Networks (RLANs)
- IMT-2000 – mobile and fixed, terrestrial and satellite
- Interactive broadcasting
- Convergence

Wireless Access Definitions

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wireless access	end-user radio connection(s) to core networks.
fixed wireless access	wireless access application in which the location of the end-user termination and the network access point to be connected to the end-user are fixed.
mobile wireless access	wireless access application in which the location of the end-user termination is mobile.
nomadic wireless access	wireless access application in which the location of the end-user termination may be in different places but it must be stationary while in use.
broadband wireless access	wireless access in which the connection(s) capabilities are higher than the primary rate (i.e., >1 544 kbit/s).

Reference: Recommendation ITU-R F.1399, "Vocabulary of terms for wireless access"

Aspects of Wireless Access

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- Mobility capabilities of the terminal
  - fixed, nomadic, mobile, restricted mobility (e.g. within a single cell), etc.
- Service support capabilities
  - narrow-band, broadband, multimedia, etc.
- Type of telecommunication service
  - conversational, distribution, information retrieval.
- Connectivity
  - e.g., Internet, PSTN, etc.
- Radio transmission technology
  - access technique (TDMA, CDMA, etc.), modulation technique (analogue, digital, etc.), duplex technique (FDD, TDD, etc.), etc.
- Delivery mechanism
  - terrestrial, satellite, etc.

Reference: Recommendation ITU-R F.1399, "Vocabulary of terms for wireless access"

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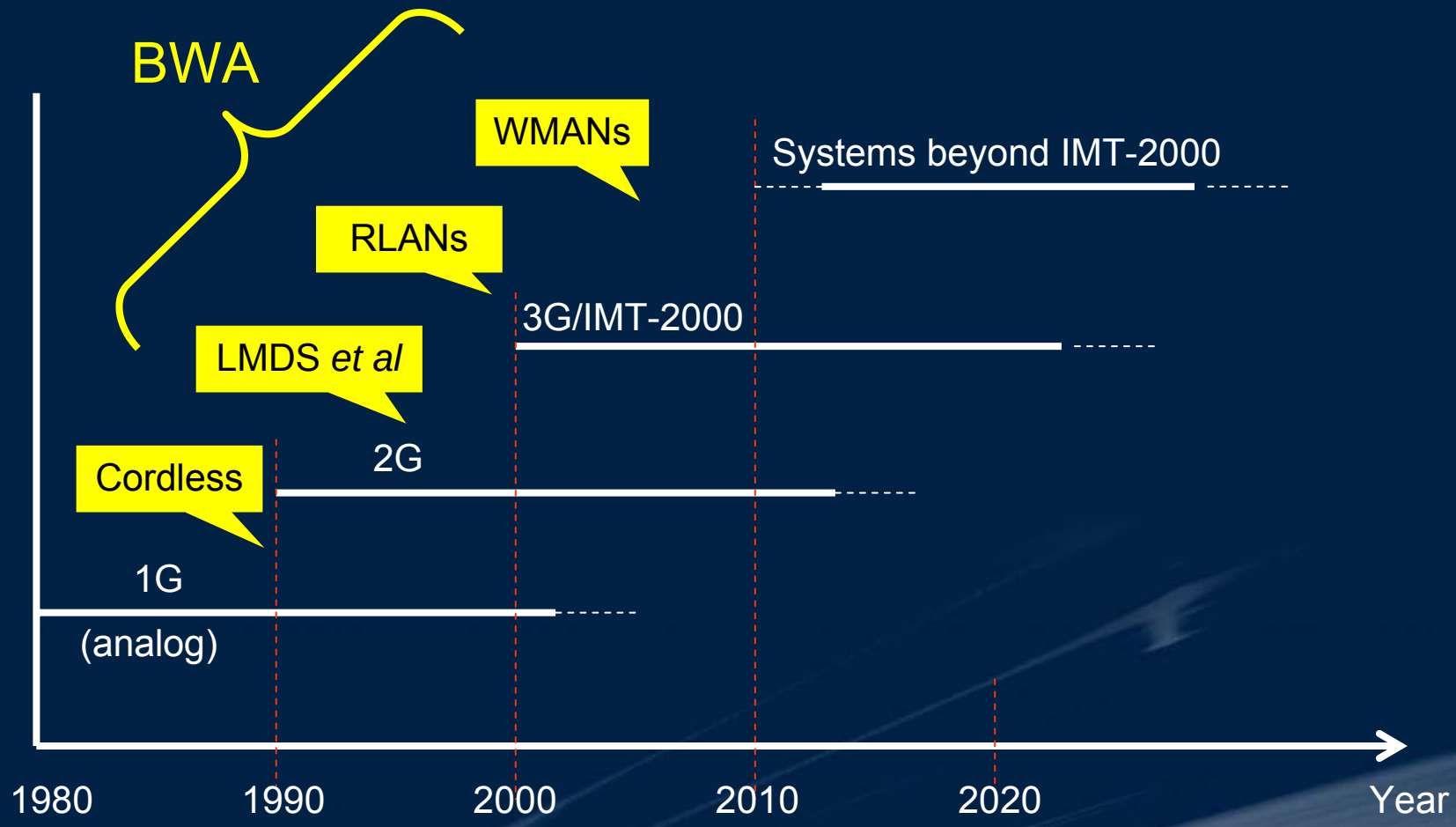
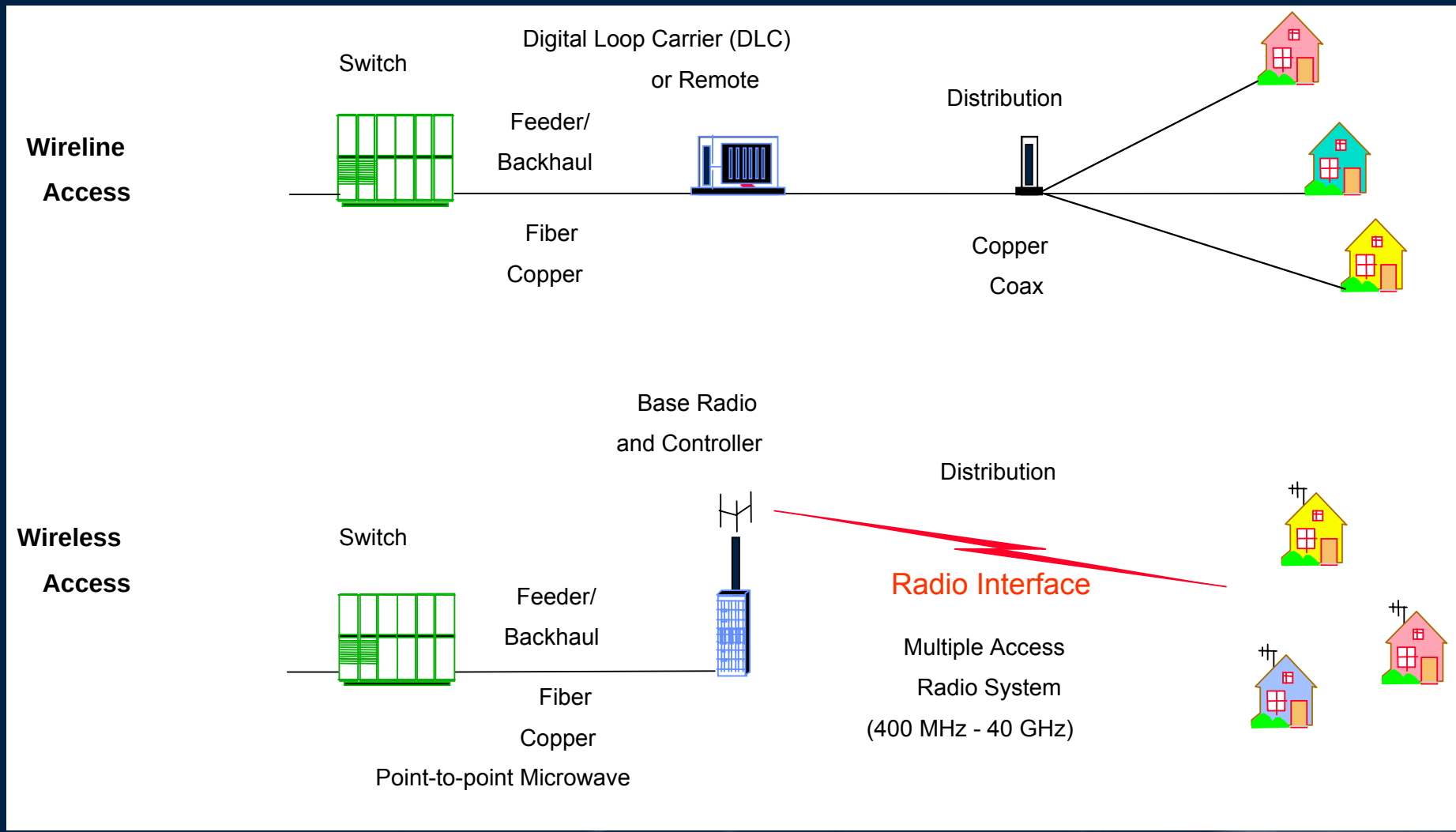
Generations of mobile wireless systems plus other radio systems



Wireline and wireless access comparison



Reference: ITU-R FWA Handbook

Comparison of wireline and wireless

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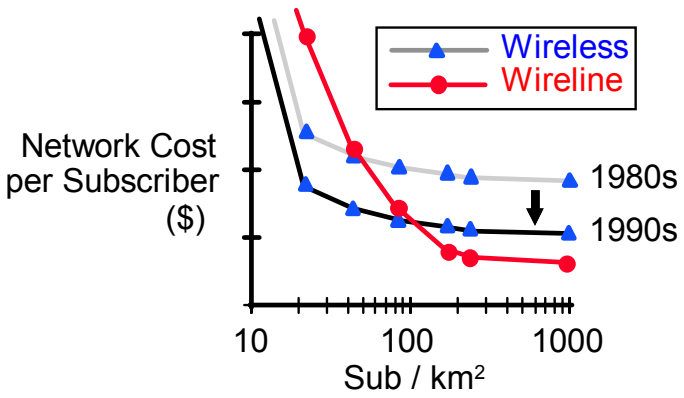
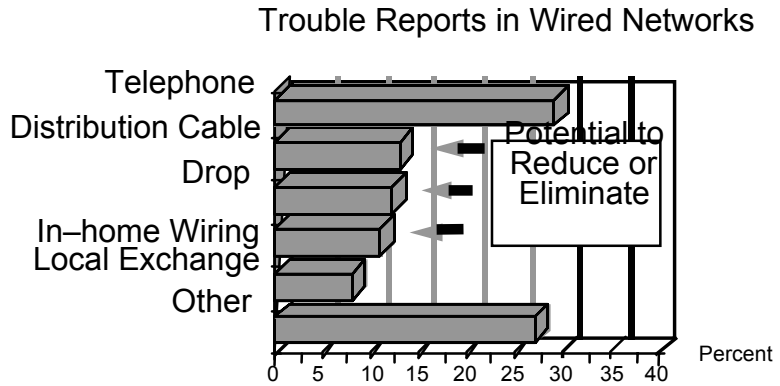
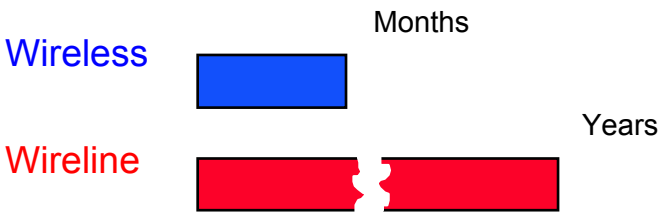
Capital Cost



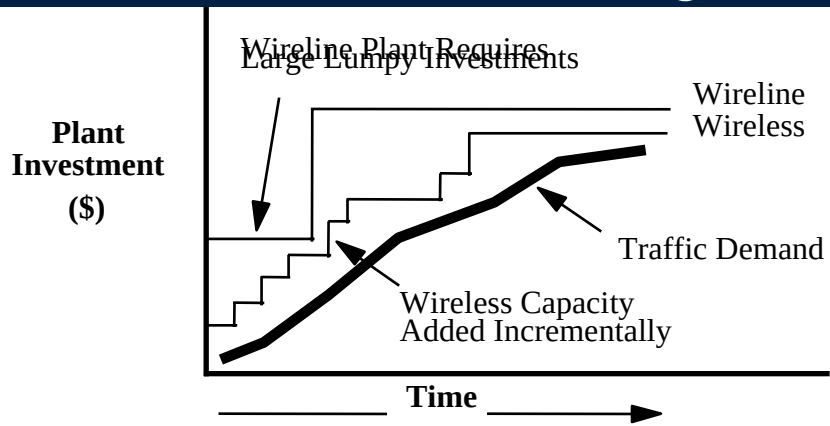
Operational Cost



Time to deploy



Flexible network design



Reference: ITU-R FWA Handbook

Origins of Wireless Access

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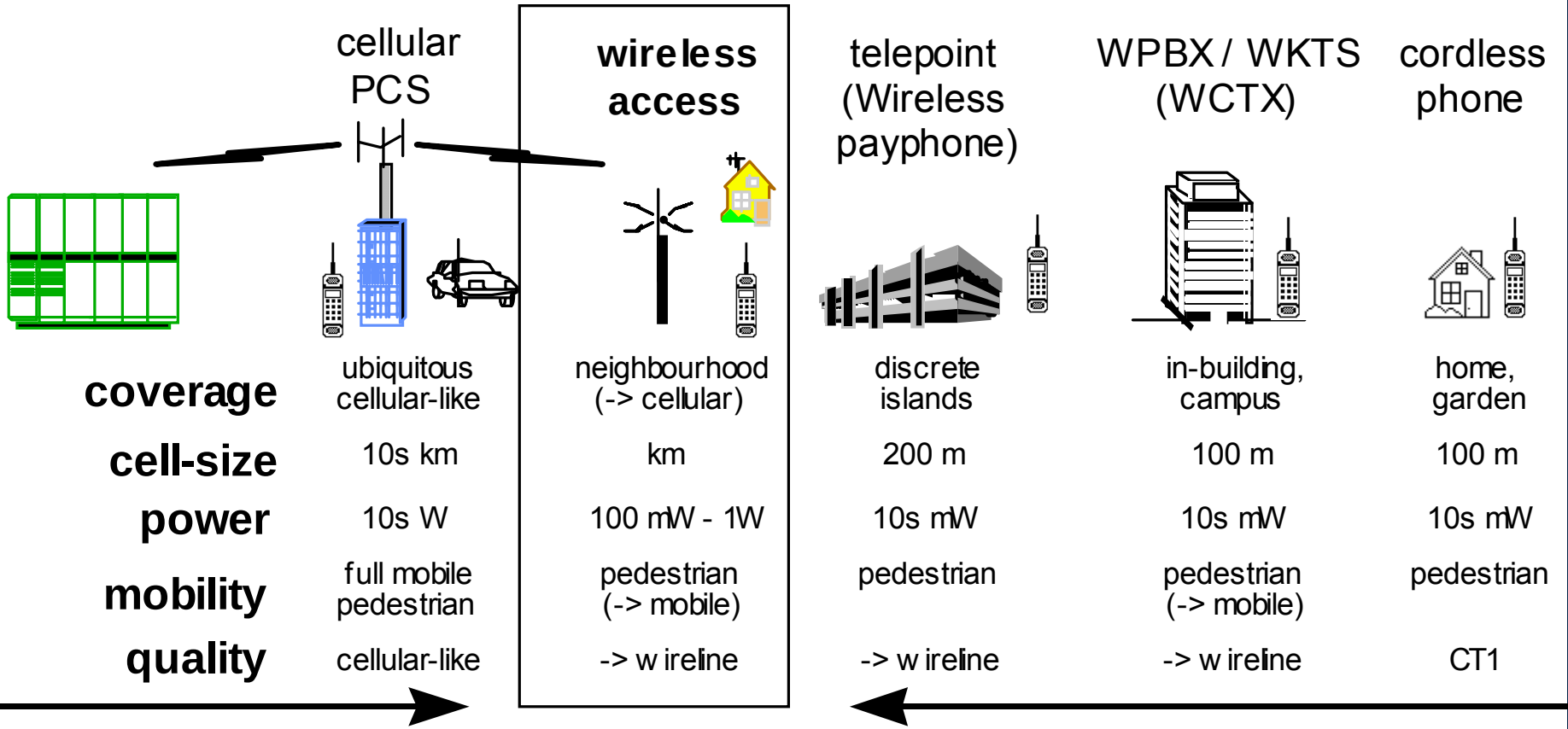

Reference: ITU-R FWA Handbook

Types of Fixed Wireless Access (FWA) Systems

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- FWA systems based on standardized mobile wireless access interfaces

Analogue Cellular (1G)	AMPS TACS NMT
Digital Cellular (2G)	D-AMPS/TDMA IS-95 CDMA GSM
Cordless Telephony	DECT PHS

- FWA systems based on proprietary radio interfaces

- Other, including broadband capabilities:
  - IMT-2000 (3G), including the terrestrial and satellite components
  - Radio Local Area Networks (RLAN)
  - Wireless Metropolitan Area Networks (WMAN)
  - Interactive broadcasting, terrestrial and satellite

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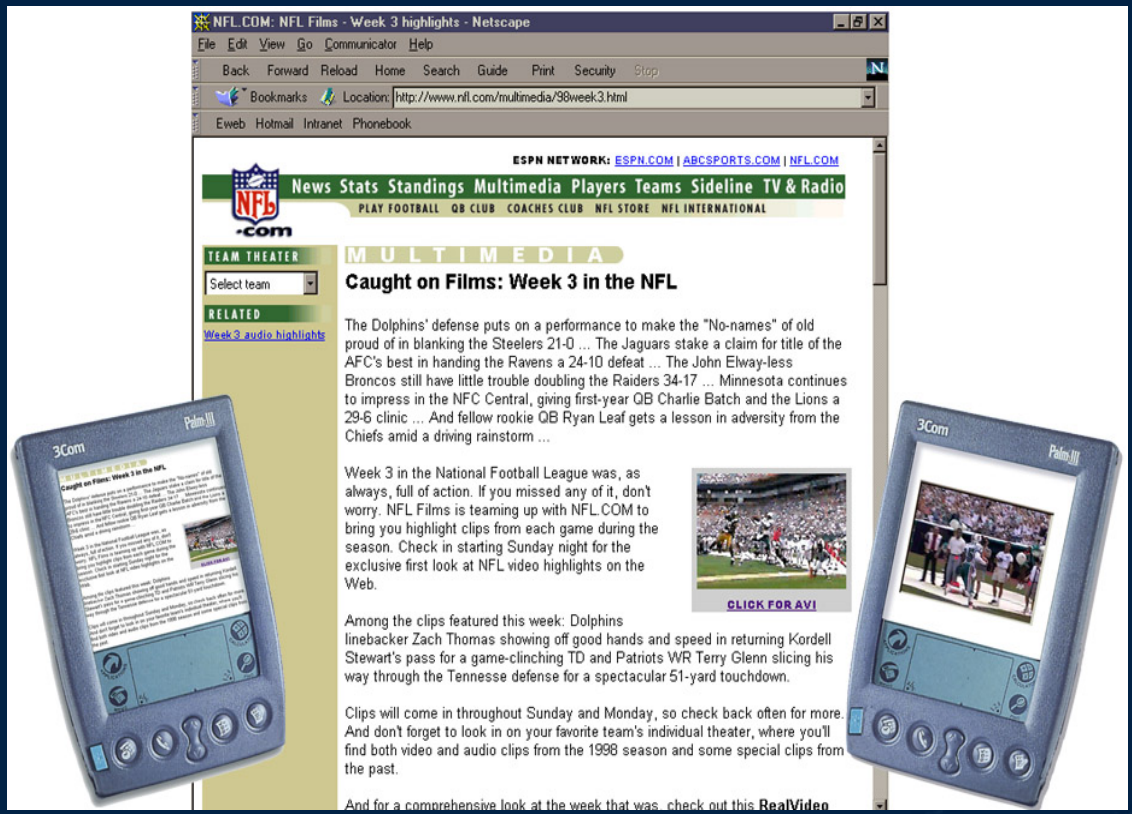
Factors that need to be considered

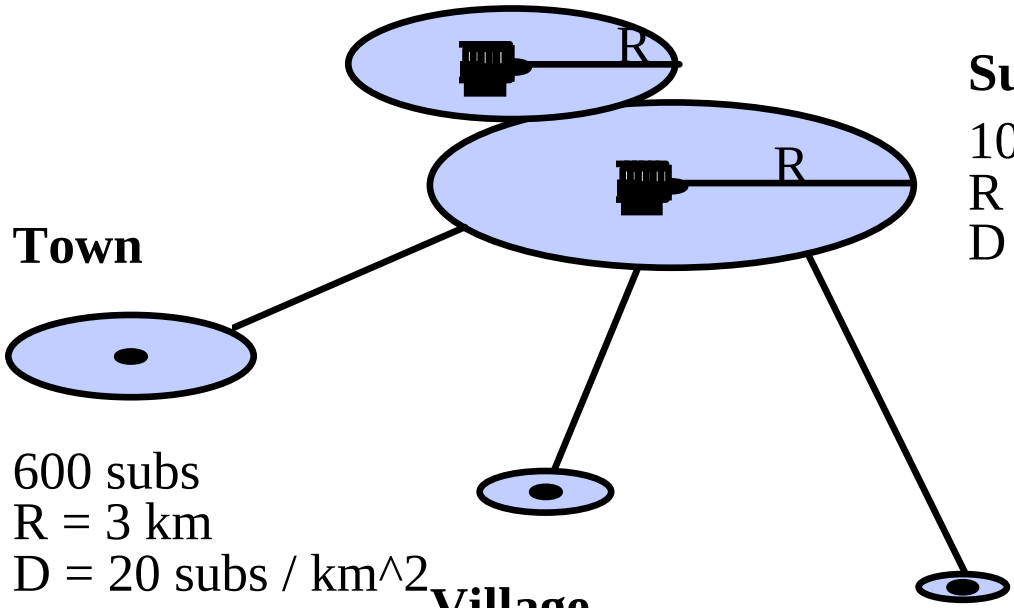


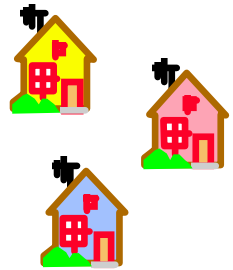
- Services
- Quality of Service
- Traffic Asymmetry
- Roaming needs
- Environment
- User Demographics

Various requirements

Urban / Industrial

25,000 subs
R = 2 km
D = 2000 subs / km^2





Suburban

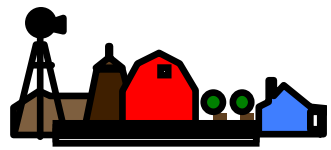
10,000 subs
R = 4 km
D = 200 subs / km^2

Town

600 subs
R = 3 km
D = 20 subs / km^2

Village

100 subs
R = 2 km
D = 10 subs / km^2



Rural

5 subs
R = 1 km
D = 2 subs / km^2

Reference: ITU-R FWA Handbook

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Performance and availability standards

- Recommendation ITU-R F.1400
- Three classifications of services for wireless access systems:
  - *Type 1*: Analogue signals such as voice and voiceband data at rates up to 64 kbit/s
  - *Type 2*: Access bearer service from 64 kbit/s to bit rates below the primary rate
  - *Type 3*: Digital services operating at the primary rate or above (broadband)
- Performance requirements and objectives
- Error performance objectives
- Availability requirements:
  - 99.99% for medium quality applications
  - 99.999% for high quality applications
- Traffic capacity
- Signal transmission delay

Quality of Service (QoS) classes from a user perspective

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QoS class of service	Conversational class of service Real-time conversation	Interactive class of service Interactive best effort	Streaming class of service Real-time streaming	Background class of service Background best effort
Fundamental characteristics from the user perspective	– Preserve time relation (variation) between information entities of the stream – Conversational pattern (stringent and low delay)	– Request response pattern – Preserve payload content	– Preserve time relation (variation) between information entities of the stream	– Destination is not expecting the data within a certain time – Preserve payload content
Example of the application	– Voice	– Web browsing	– Streaming video	– Background download of e-mails

Reference: Recommendation ITU-R M.1079-2, "Performance and quality of service requirements for IMT-2000 access networks "

Example of Cost Comparisons

(Coopers & Lybrand Study, 1995)

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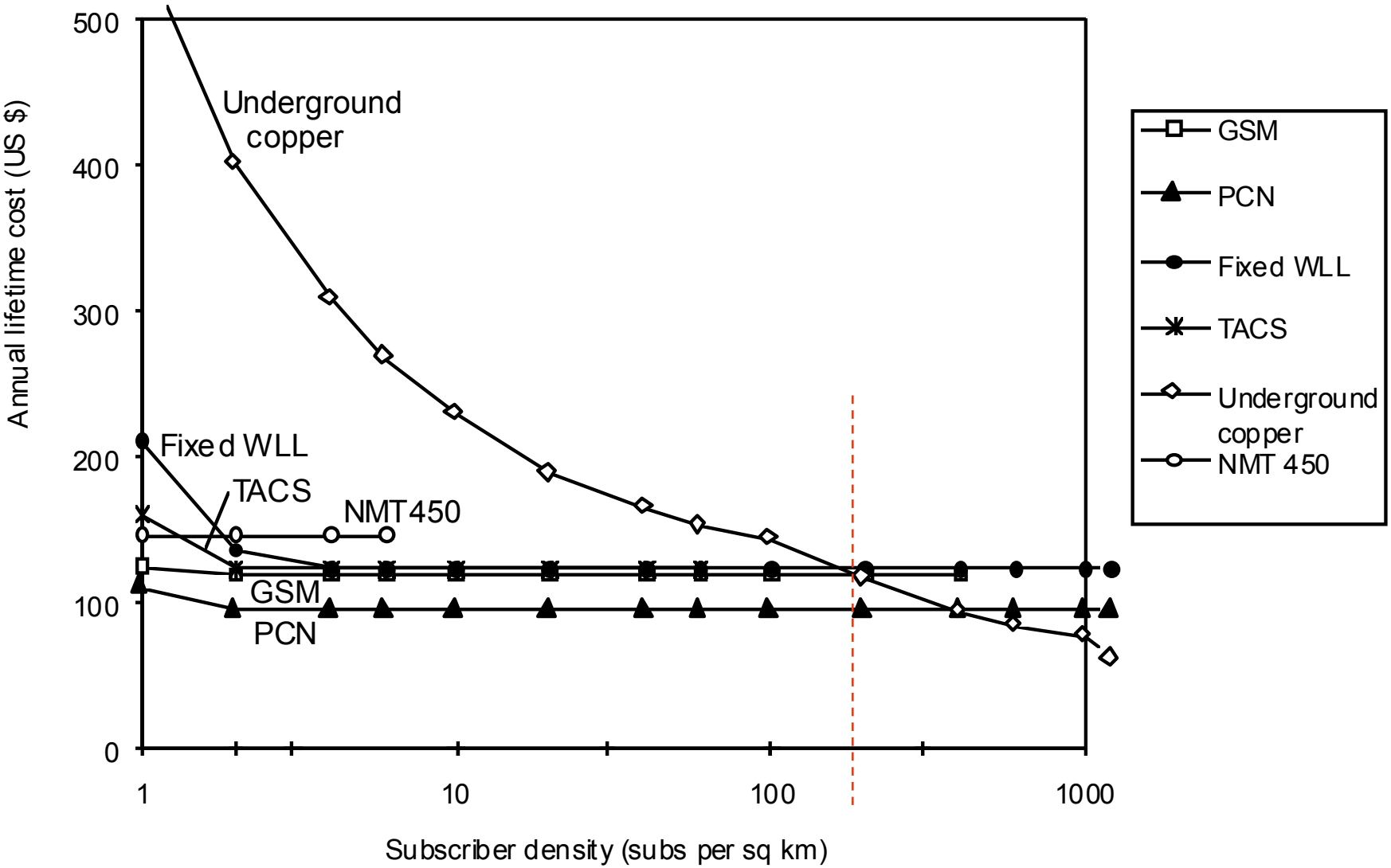

Reference: ITU-R FWA Handbook

The need for spectrum: Radiocommunication Services enable wireless communication services

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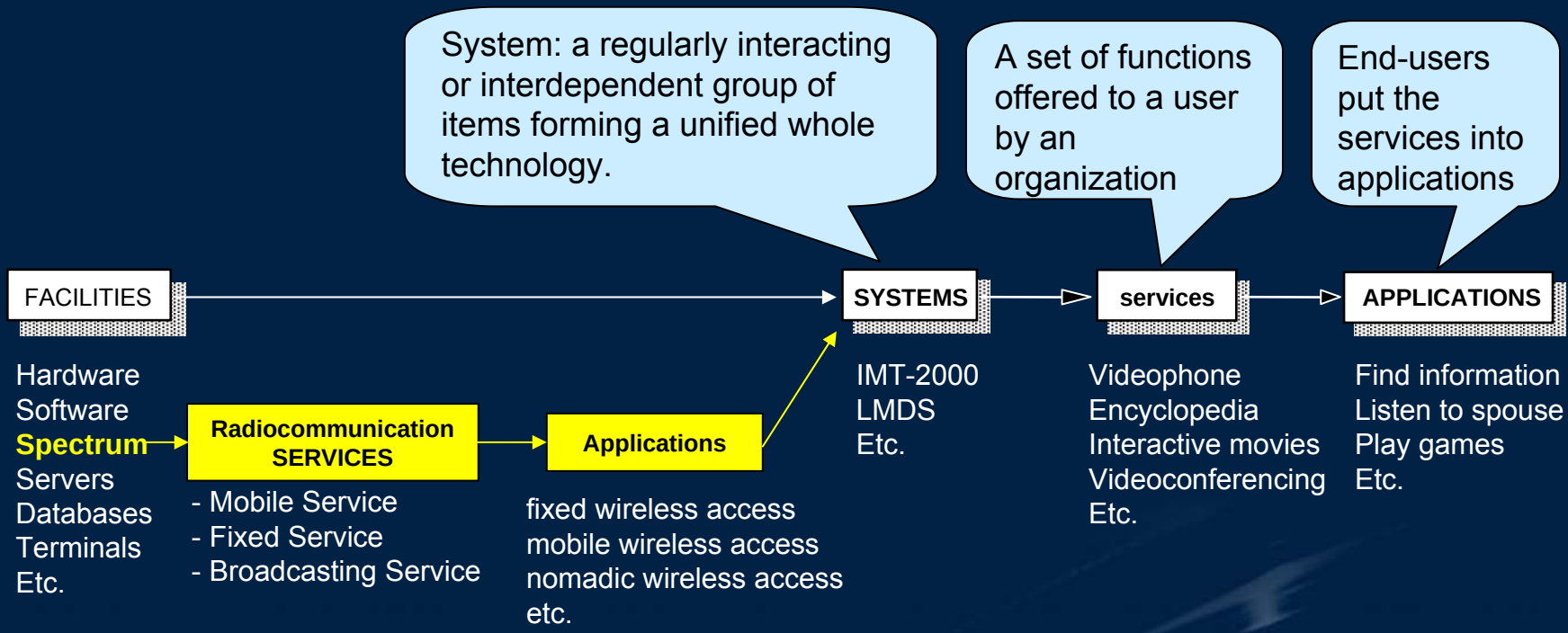

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Frequency Spectrum Allocation: World Radiocommunication Conferences

- The ITU World Radiocommunication Conferences (WRCs) allocate the frequency spectrum to Radiocommunication Services, and the agreements are included in the ITU Radio Regulations, which are treaty-binding.
- There is a long preparatory process for each WRC
- Examples of Radiocommunication Services:
  - Mobile Service (MS)
  - Fixed Service (FS)
  - Mobile Satellite Service (MSS)
  - Fixed Satellite Service (FSS)
  - etc.

No spectrum, no wireless applications!

From ITU Radio Regulations to End-Users of the Spectrum

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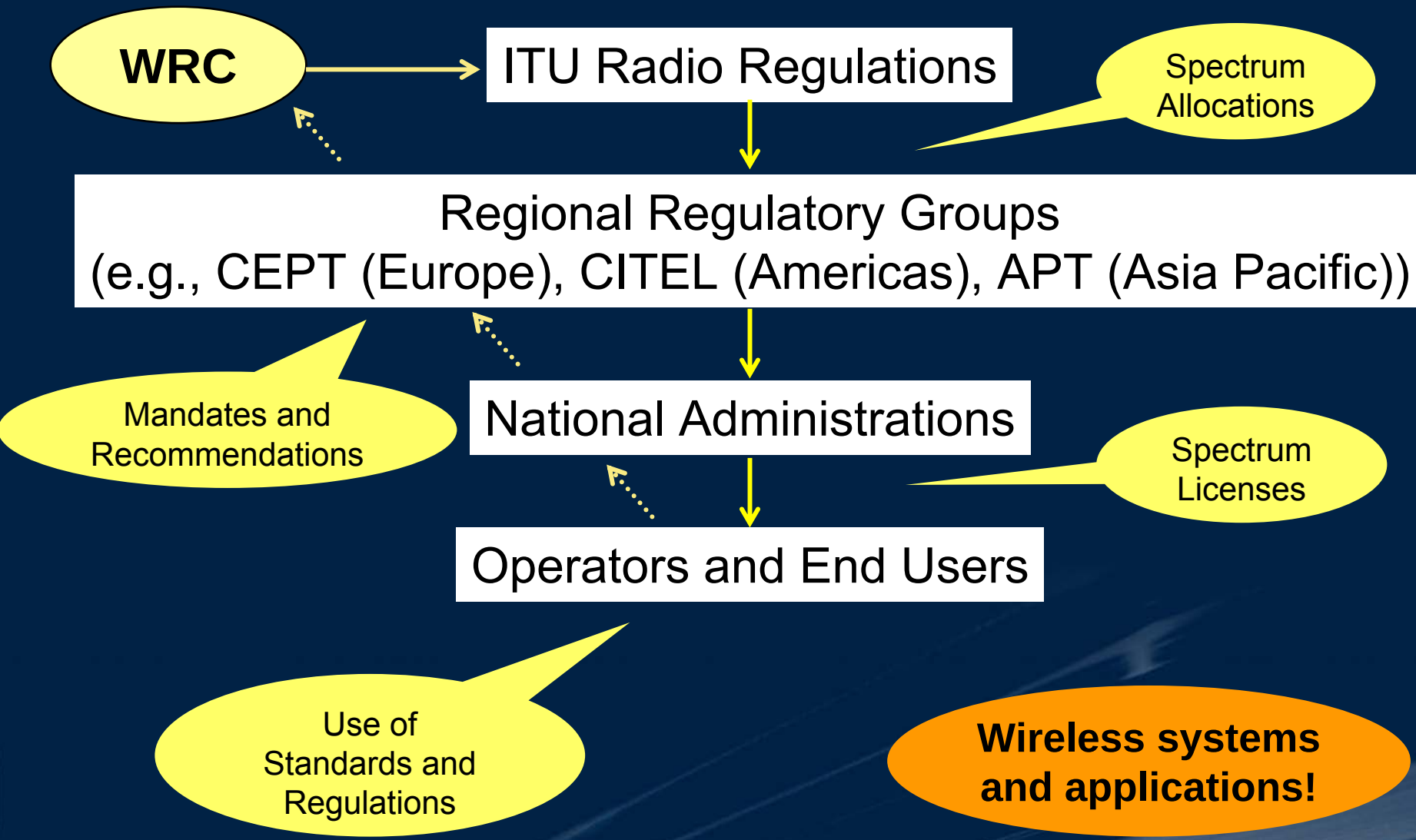

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Identification of Frequency Bands

- Recommendation ITU-R F.1401-1
- Spectrum characteristics are described for these ranges: below 1 GHz, 1-3 GHz, 3-10 GHz, 10-30 GHz, 30-50 GHz and above 50 GHz
- Frequency bands broadly categorized by service and constituency
- Methodology to identify possible bands (7 step procedure)
- Information to be compiled for the identification of frequency bands
- Examples of frequency bands (450 MHz, 800-900 MHz, 1.8/1.9 GHz, 3.5 GHz, 24/29 GHz, 32 GHz, 38 GHz, 40 GHz):
  - Frequency range and reference ITU−R Recommendation for frequency arrangements
  - Frequency band
  - RF carrier spacing
  - Reference ITU-R Recommendations for sharing considerations (with other services)

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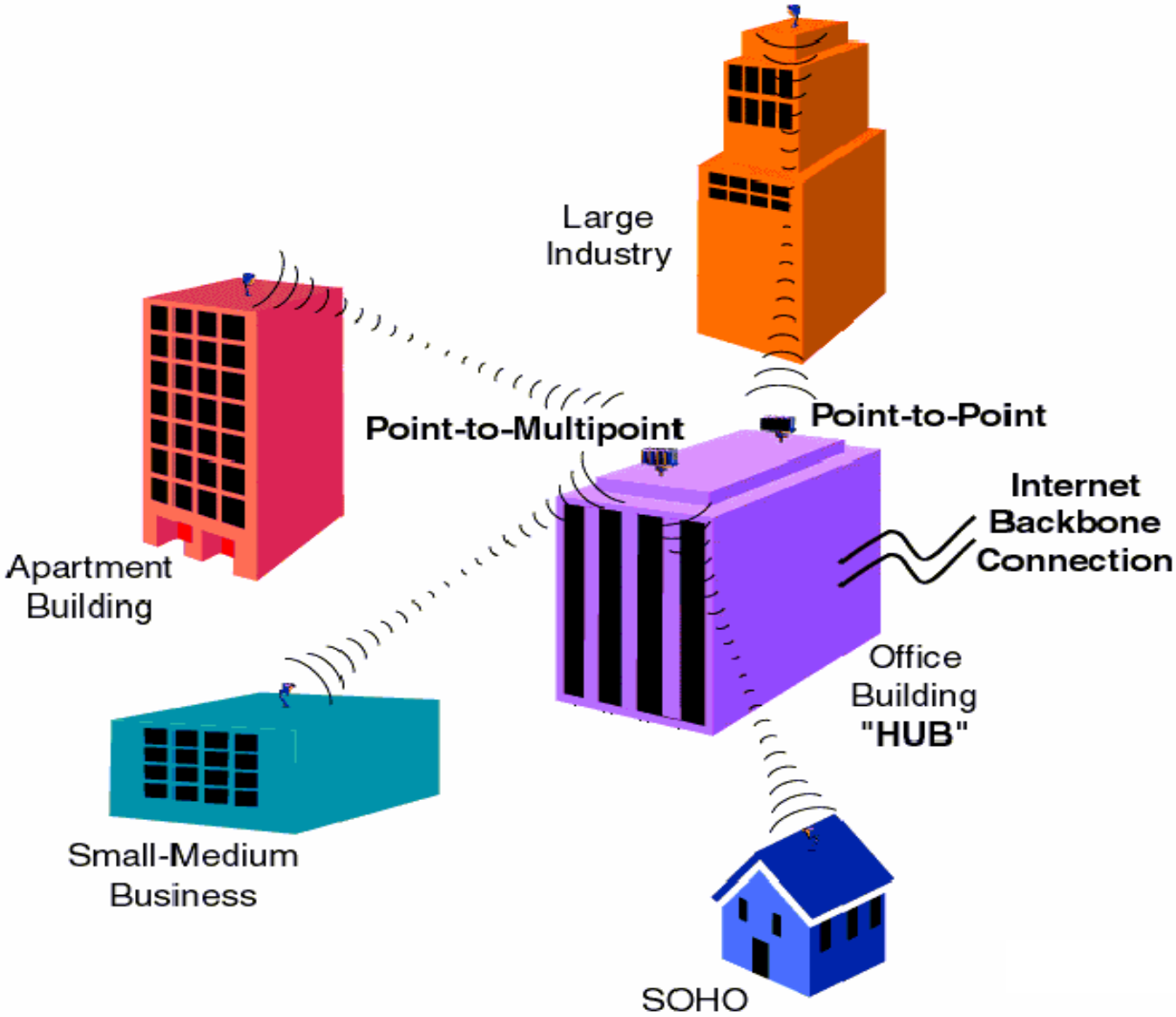
Broadband Wireless Access



Reference: ITU-R FWA Handbook

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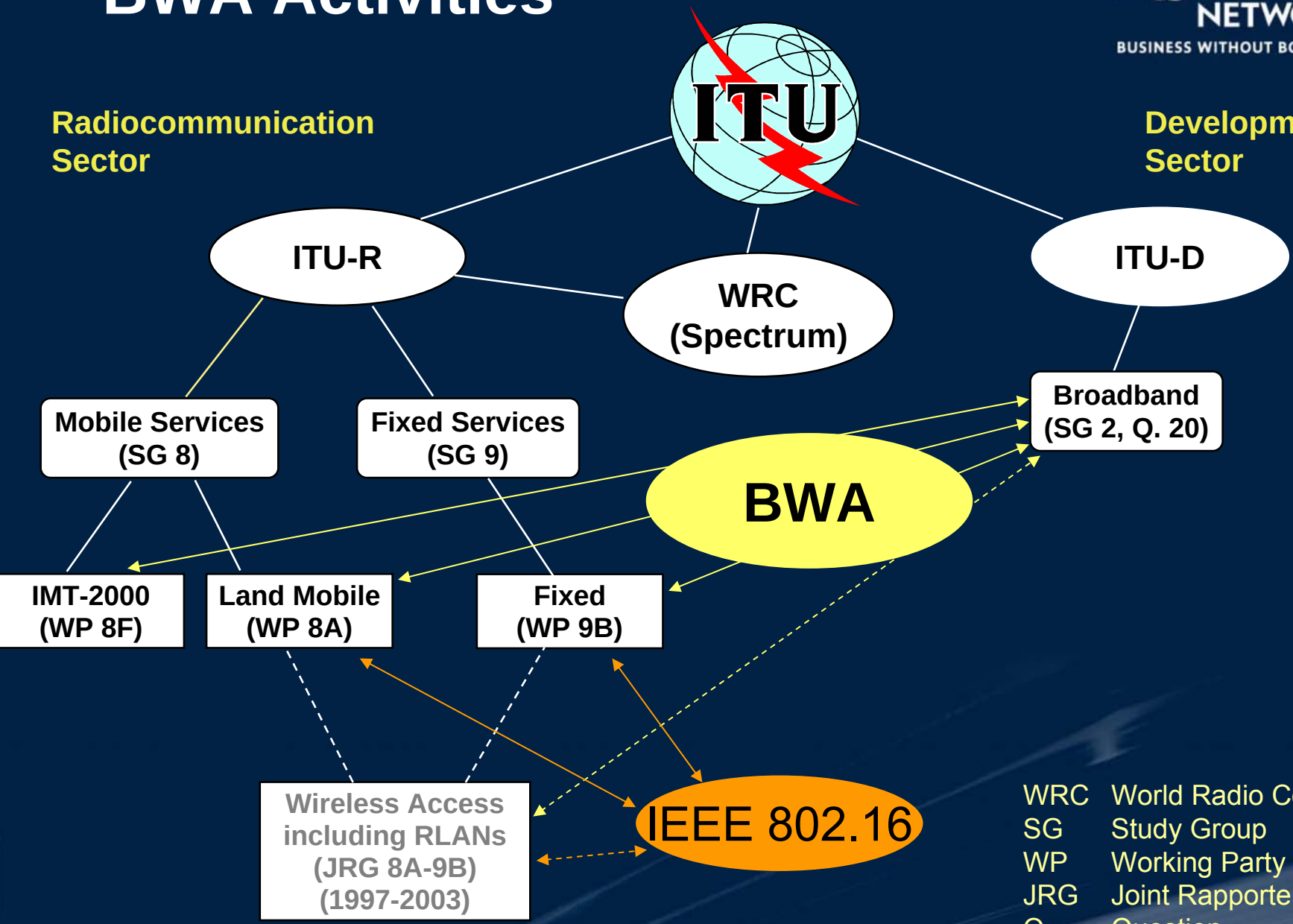
BWA Standards – Year 2000

- Recommendation ITU-R F.1499, "Radio transmission systems for fixed broadband wireless access based on cable modem standards"
  - This Recommendation is based on the standards approved and published by ITU-T for cable modems (specifically ITU-T Recommendation J.112, Annex B), but adapts the technical parameters for use in the wireless access environment, that is for BWA customer premises equipment (CPE) modems. The commonality is maximized to achieve economies of scale.
  - This Recommendation is complementary to ITU-T Recommendation J.116, which standardizes the MAC layer.
  - Enables transparent bidirectional transfer of ATM and/or IP traffic, between the BWA base stations and customer locations, over a BWA network.

BWA Standards – Year 2004

- Ongoing relationship between ITU, IEEE and ETSI to incorporate the IEEE 802.16 and ETSI BRAN BWA standards in ITU Recommendations.
  - Draft new Recommendation for fixed wireless access originally developed in ITU-R JRG 8A-9B and now being continued in Working Party 9B for the Fixed Service.
  - Includes the IEEE WirelessMAN standards (IEEE 802.16) and ETSI HiperMAN standards (ETSI BRAN).
  - There is another relationship between IEEE 802.16 and ITU-T Study Group 9 (cable modem standards) to investigate the synergism between IEEE 802.16 and cable networks.
- Wireless Metropolitan Area Networks (WMANs)

BWA Activities



WRC World Radio Conference
SG Study Group
WP Working Party
JRG Joint Rapporteur Group
Q Question

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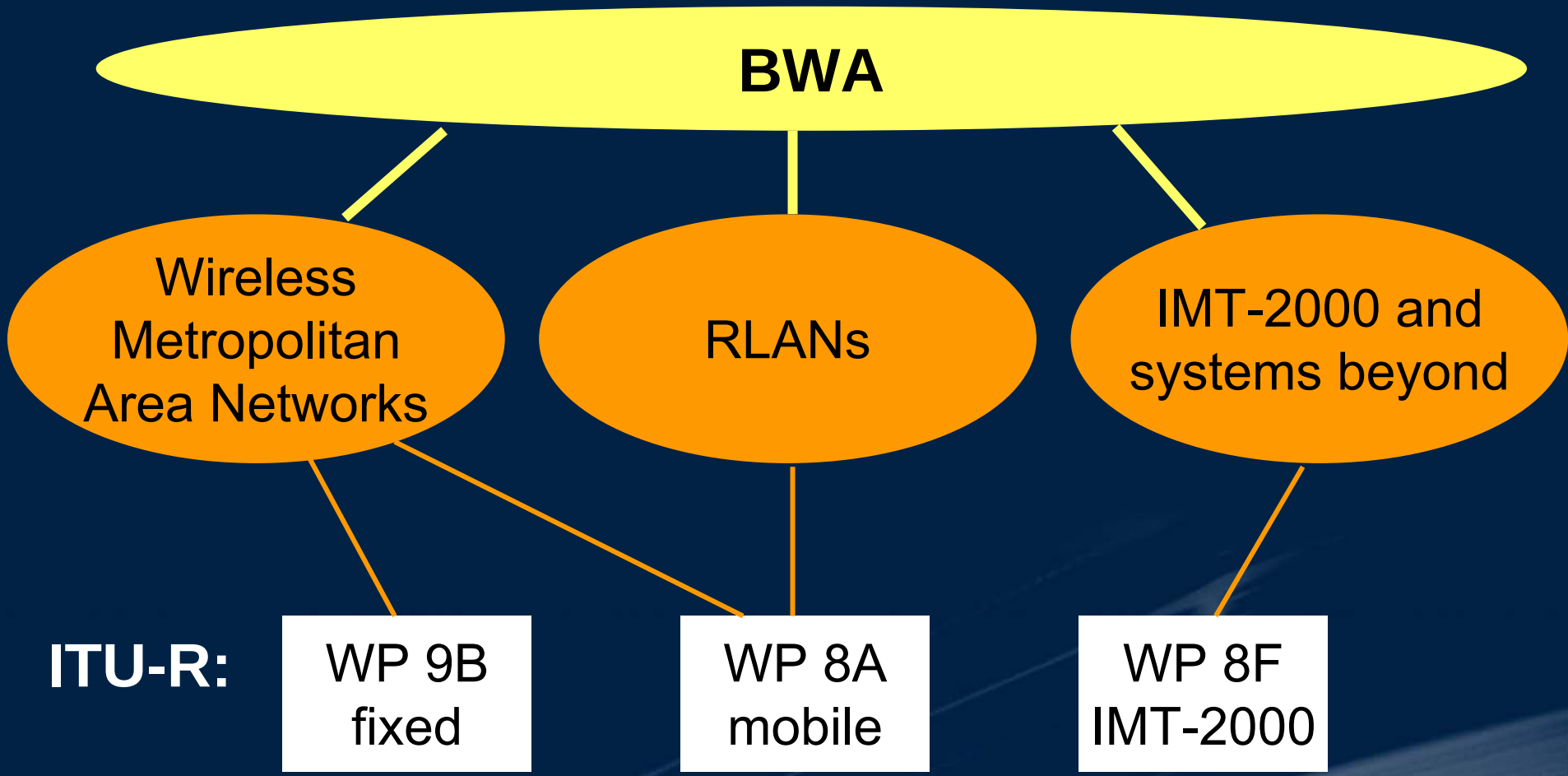
BWA Systems and Standards



Wireless Access Systems (WAS)

Wireless Access Systems (WAS) are defined as end-user radio connections to public or private core networks. Technologies in use today for implementing wireless access include cellular, cordless telecommunication, and wireless local area network systems.

Advances in technology and competitive access are driving the revolution towards wireless access infrastructure. Traditionally, the most difficult component of the network to build and the least cost-effective to maintain has proven to be the local access network regardless of a developing or a developed economy. As a result, fixed wireless access to the core network has proven to be an effective alternative in the provision of basic telephone service.

Public and private WLAN (or RLAN) systems are quickly emerging as a preferred access technology. In conjunction with the deployment of IMT-2000, WLAN gives operators an opportunity to expand both overall market size and competitive position for data services.

The ITU Radiocommunication Sector is actively participating in the development of WAS and its main activities comprise international standardization, including frequency spectrum and technical specifications.

- ITU and WAS
- ITU and Broadband
  - Promoting Broadband
  - Regulatory implications of Broadband
  - Broadband access technologies
  - ITU All Star network Access Workshop (Geneva, 2-4 June 2004)

About WAS

- Handbook
- Useful links
- IMT-2000
- Global Standards Collaboration
- Contact WAS

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Broadband Radio Local Area Networks

- Recommendation ITU-R M.1450, “Characteristics of broadband radio local area networks”
- Data rates of up to 54 Mbit/s
- Frequency bands include:
  - 2 400 - 2 483.5 MHz
  - 5 150 - 5 250 MHz
  - 5 250 - 5 350 MHz
  - 5 725 - 5 825 MHz
- Systems include:
  - IEEE Project 802.11b
  - IEEE Project 802.11a
  - ETSI BRAN HIPERLAN 1 (ETS 300-652)
  - ETSI BRAN HIPERLAN 2
  - MMAC HSWA HiSWAN a (Japan)

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Relevant WRC-03 results

- 455 MHz have been newly allocated to the Mobile Service on a primary basis for use by RLANs in the 5 GHz band:
  - 5150-5250 MHz, 5250-5350 MHz and 5470-5725 MHz.
- The operation of EESS, SRS and Radiolocation systems are protected through the adopted technical limits.
- Technical limits (Resolution 229 (WRC-03)):
  - 5150-5250 MHz: 200 mW e.i.r.p. (max), indoor only
  - 5250-5350 MHz: Dynamic Frequency Selection (DFS) and Transmitter Power Control (TPC) are required; 200 mW e.i.r.p., predominantly indoor use but outdoor use is also allowed; for >200 mW need an e.i.r.p. mask
  - 5470-5725 MHz: DFS and TPC are required; 1 W e.i.r.p. (max), 250 mW transmitter power (max)

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RLANs in 5 GHz bands

- In addition to the WRC-03 allocations, 125 MHz of spectrum (5 725 – 5 850 MHz) are also available for use in some countries on a national basis (and 83.5 MHz are already in use in the 2.4 GHz band by RLANs)
- Strong commercial interest (licence-exempt equipment)
- Can provide broadband solutions, both urban and rural

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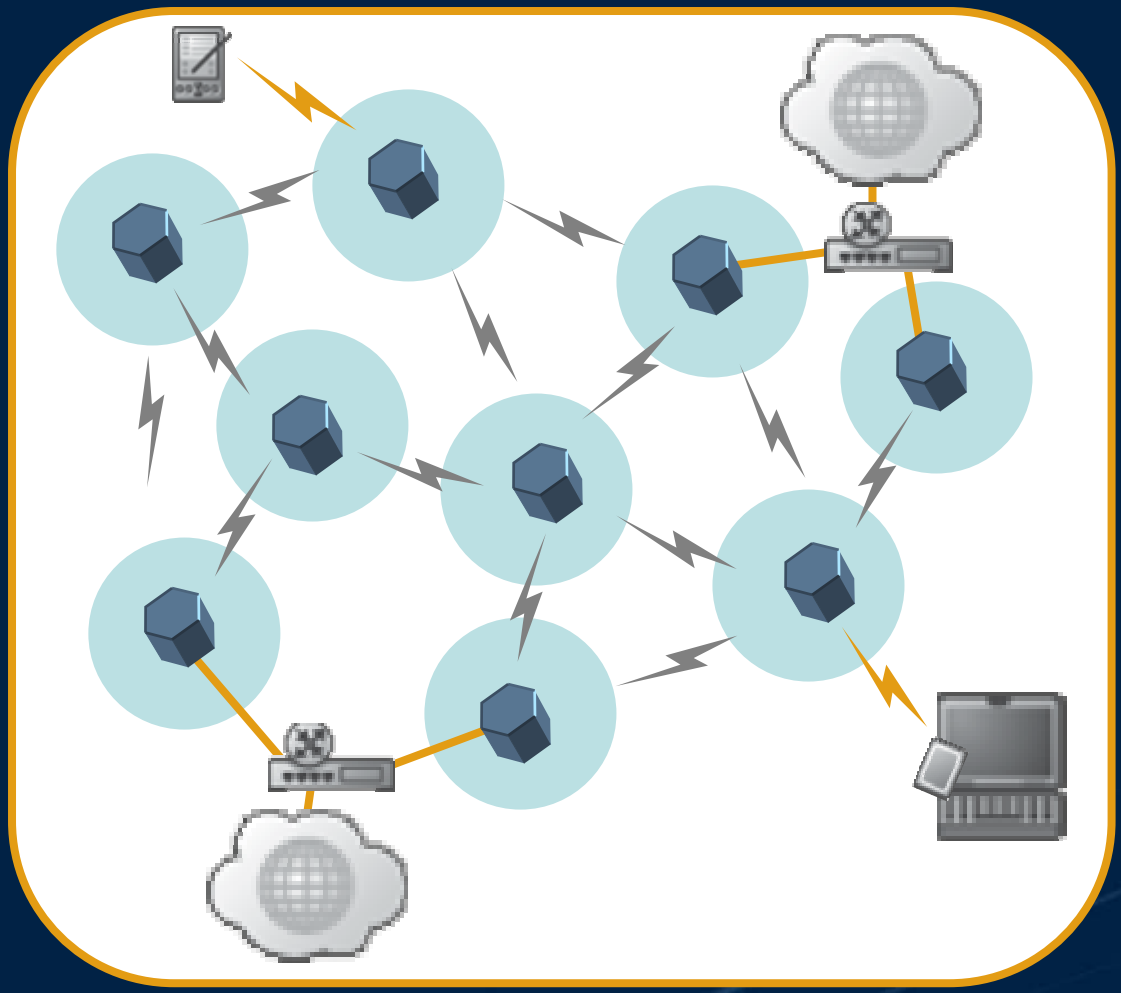
Example of applications

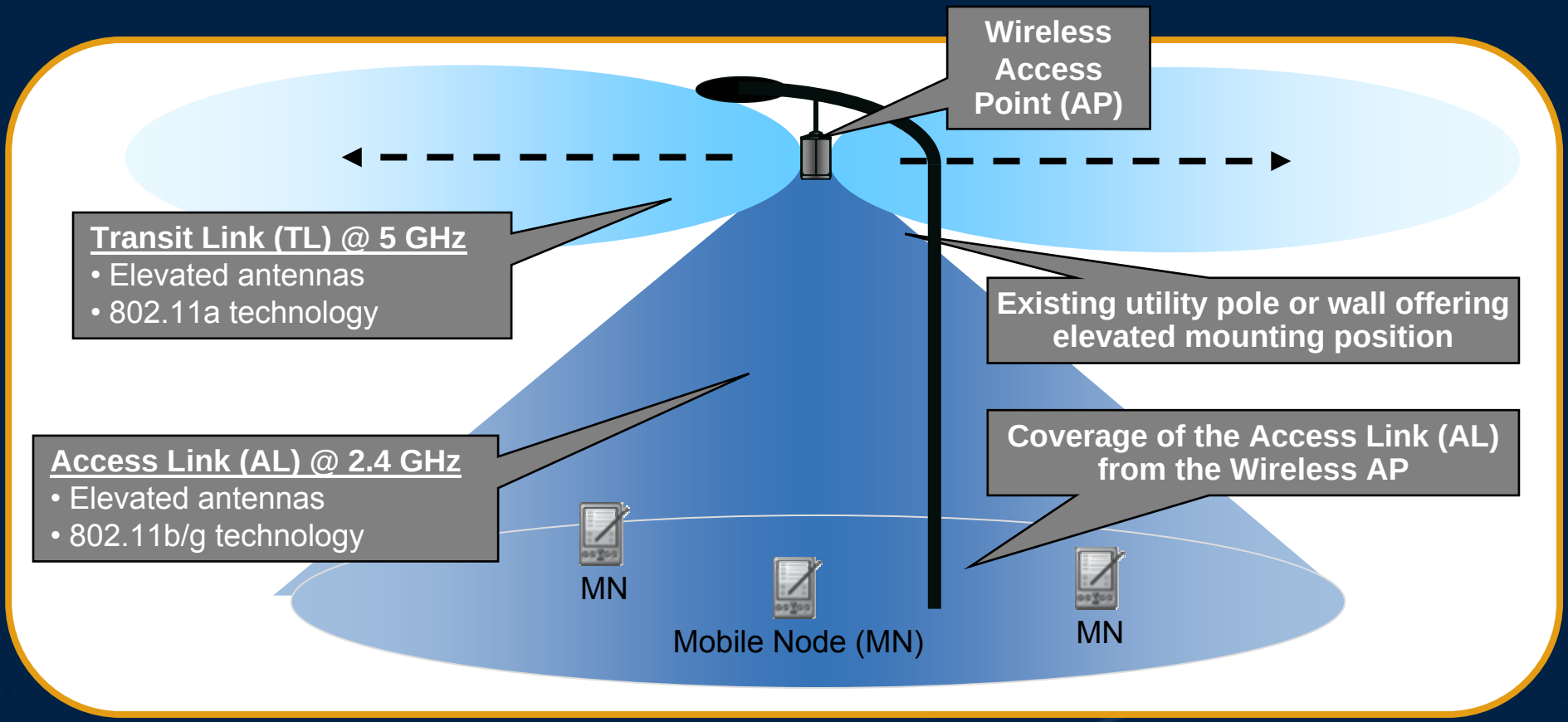
Wireless mesh networks using RLAN technology

Wireless Mesh Networks



- **Key characteristics**
  - Auto-discovery of nodes and routes
  - Auto-configuration of network components
  - Mesh topology
  - Wireless interconnection
- **Advantages**
  - Rapid network deployment
  - Reduced infrastructure costs
  - Reduced engineering and operational costs
  - Increased network reliability

Radio networking technology



Radio links separated in space and frequency, combined with adaptive interference control

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IMT-2000 - Background

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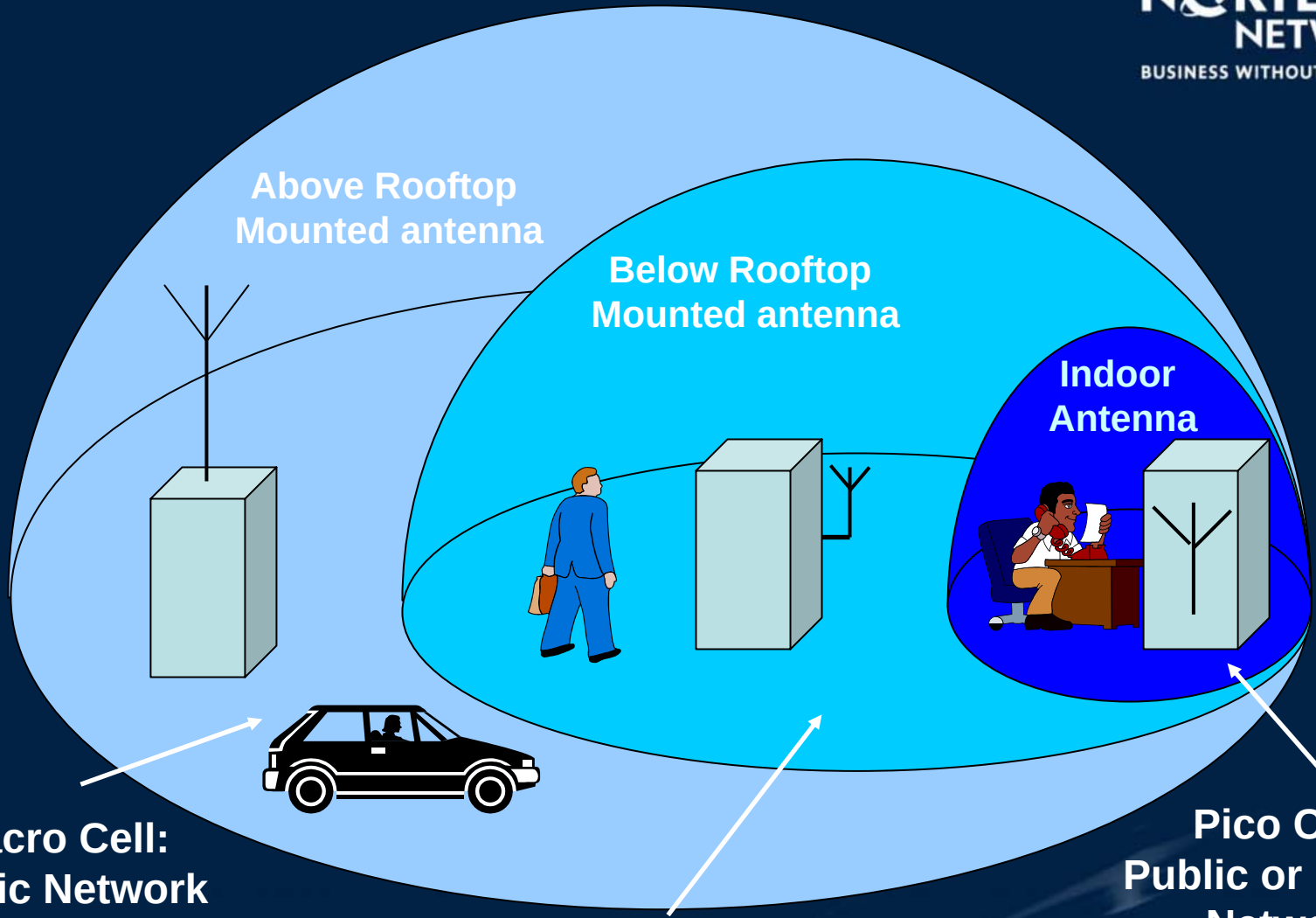
- Motivation for global mobile systems, IMT-2000 (originally labeled as FPLMTS), started around the year 1985:
  - small terminal
  - worldwide
  - mobile and fixed applications
  - terrestrial and satellite components
- 1985-1992: Concept definition and spectrum requirements
- WARC-92: identified spectrum
- 1992-1997: standardization
- 1997-2000: ongoing enhancements of the standard, trials and estimation of additional spectrum requirements
- WRC-2000: identified additional spectrum
- 2000: initial deployments
- >2000 ongoing enhancements and deployments
- Workplan for systems beyond IMT-2000

Hierarchical Cell Structures and Typical Uses



Macro Cell:
Public Network
Provides coverage for basic 3G services

Micro Cell: Public Network
Adds enhanced data rate capability to network

Pico Cell:
Public or Private Network
Adds capacity and supports highest data rate

IMT-2000 terrestrial radio interfaces

(Recommendation ITU-R M.1457)

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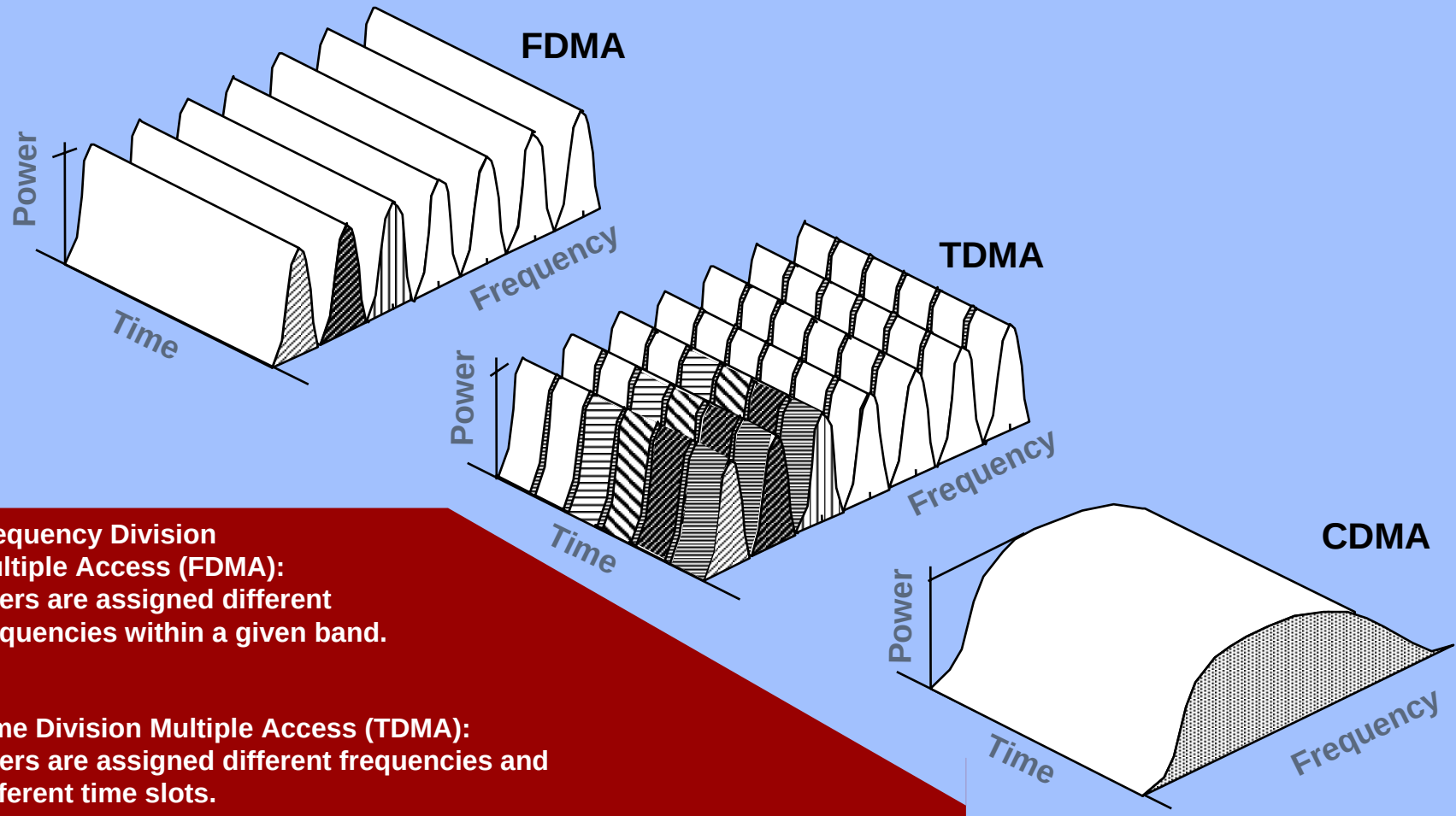
Full Name	*Short*	*Common Names*
IMT-2000 CDMA direct spread	IMT- DS	UTRA FDD WCDMA UMTS
IMT-2000 CDMA multi-carrier	IMT- MC	CDMA2000 1x and 3x CDMA2000 1xEV-DO CDMA2000 1xEV-DV
IMT-2000 CDMA TDD (time-code)	IMT- TC	UTRA TDD 3.84 Mchip/s high chip rate UTRA TDD 1.28 Mchip/s low chip rate (TD-SCDMA) UMTS
IMT-2000 TDMA single-carrier	IMT- SC	UWC-136 EDGE
IMT-2000 FDMA/TDMA (frequency-time)	IMT- FT	DECT

Reference: ITU Handbook on Deployment of IMT-2000 Systems

Fundamentals of Multiple Access Schemes

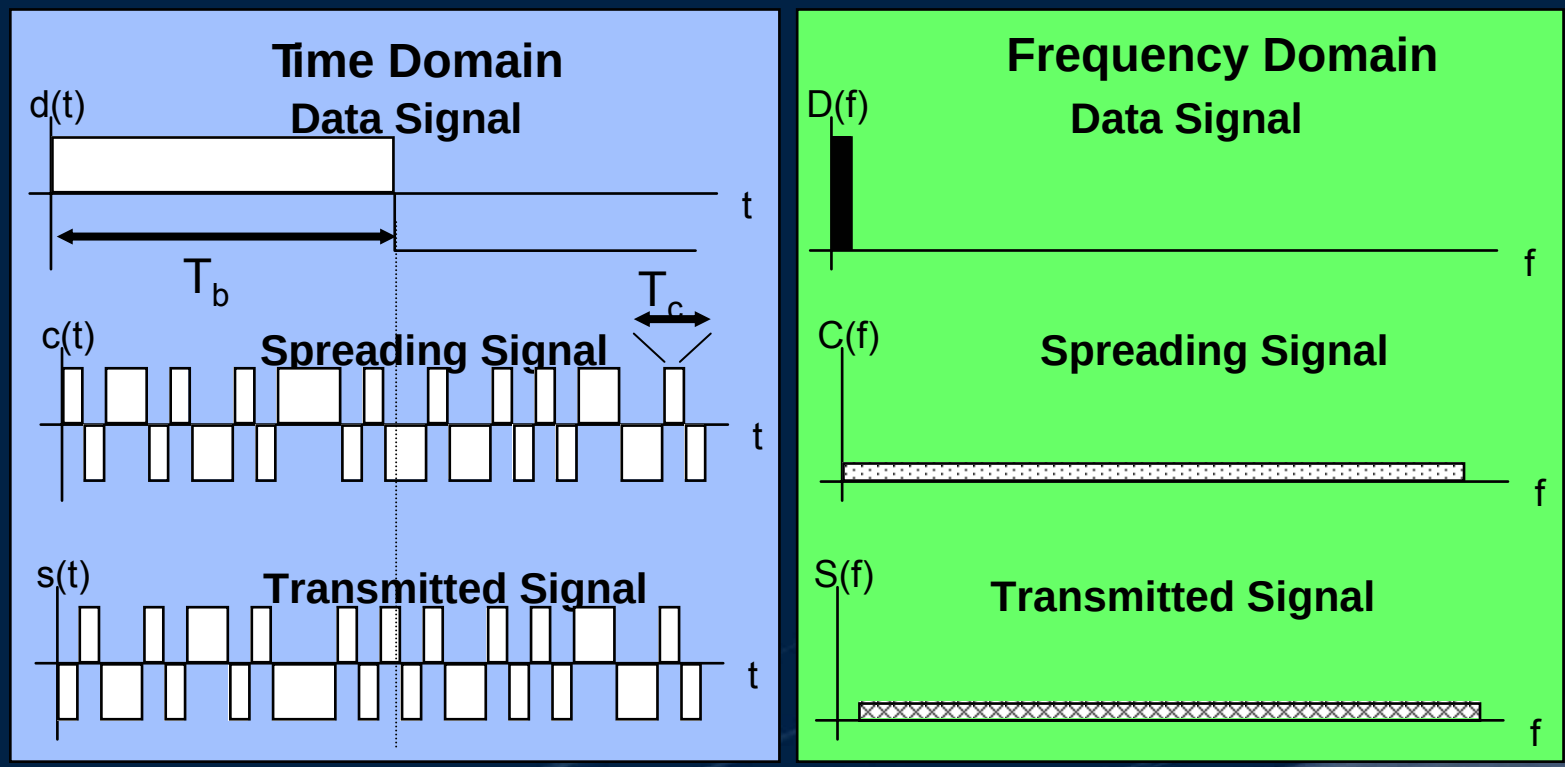


- **Frequency Division Multiple Access (FDMA): Users are assigned different frequencies within a given band.**
- **Time Division Multiple Access (TDMA): Users are assigned different frequencies and different time slots.**
- **Code Division Multiple Access (CDMA): Users are channelized by specified *codes* within a frequency band.**

Reference: ITU Handbook on Deployment of IMT-2000 Systems

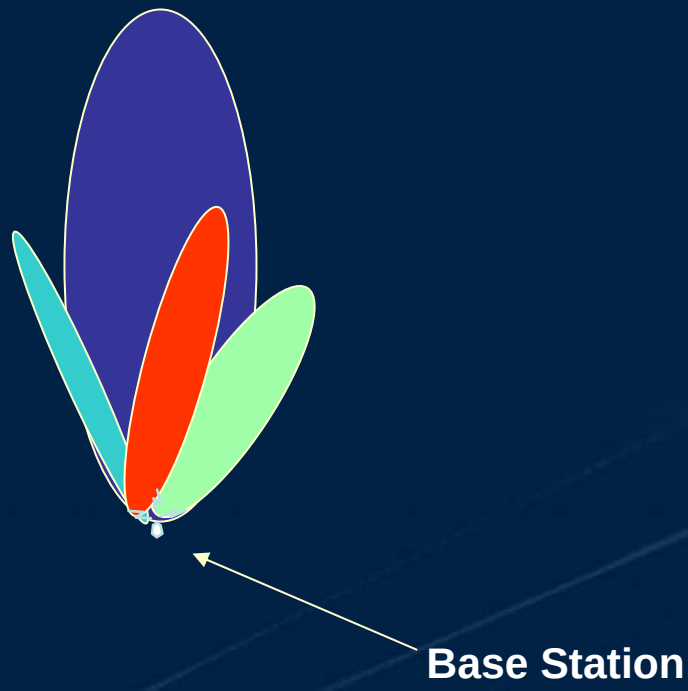
Fundamentals of Direct Spread CDMA

- The narrow band signal (characterised by bit duration T_b) is spread by a wide-band signal (spreading code) (characterised by Chip duration T_c or chip rate $R_c=1/T_c$)
- Spreading factor SF= T_b/T_c

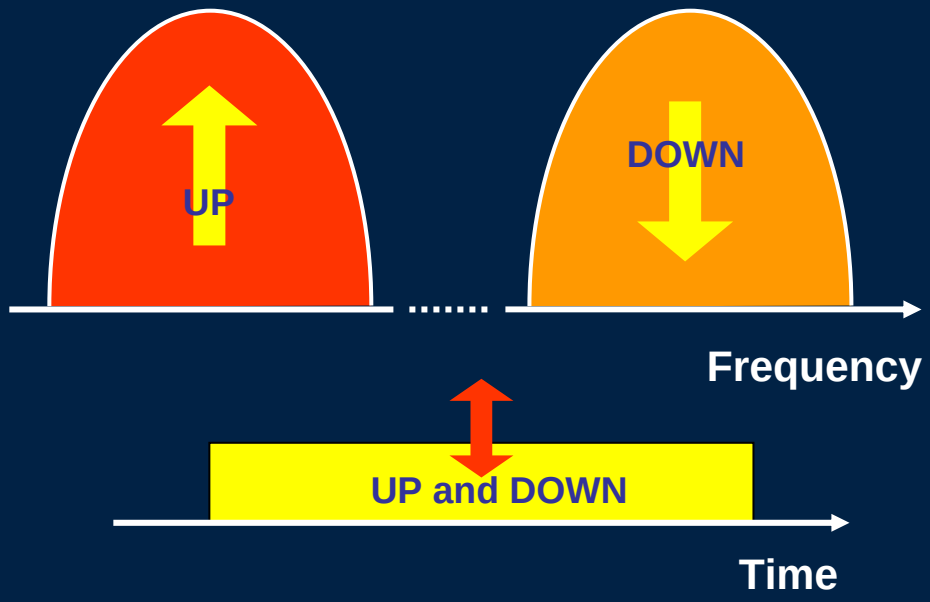


Space Division Multiple Access (SDMA)

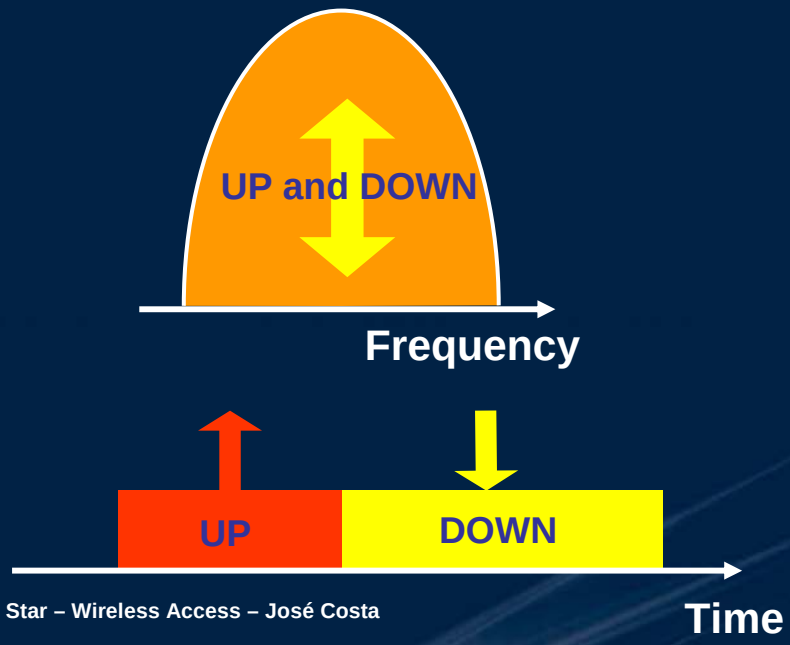
- May be used in combination with any of the other multiple access techniques.



Duplex Schemes



- Frequency Division Duplex (FDD)
  - Good for large distances/cells
  - Good for high power
  - Does not require frame synchronization
  - Requires two block allocations



- Time Division Duplex (TDD)
  - Good for short distances (indoor and campus environments)
  - Good for low power
  - RF channel reciprocity
  - Requires frame synchronization
  - Requires one block allocation
  - Longer time delay

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Frequency spectrum requirements

- Spectrum may need to be shared with other Radiocommunication Services in the same band and might not all be available everywhere.

- For IMT-2000, 749 MHz of spectrum have been identified:
  - 806-960 MHz
  - 1 710-2 025 MHz
  - 2 110-2 200 MHz
  - 2 500-2 690 MHz

- More spectrum may be needed for systems beyond IMT-2000 from the year 2010 onwards; this will be addressed at WRC-07.

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Relationship of IMT-2000 with other radio systems

- RLANs, WMANs and broadcasting can be synergistic with mobile (cellular) networks such as IMT-2000
- While the capabilities of cellular networks such as IMT-2000 offer extensive mobility features and cost-effective wide area coverage, RLANs enable high-quality data throughput capacity in specific areas (hotspots)
- Currently, broadband RLANs enable data rates of up to 54 Mbit/s (Recommendation ITU-R M.1450)
- A single device may support different technologies (e.g., IMT-2000, RLAN, short-range connectivity) operating simultaneously

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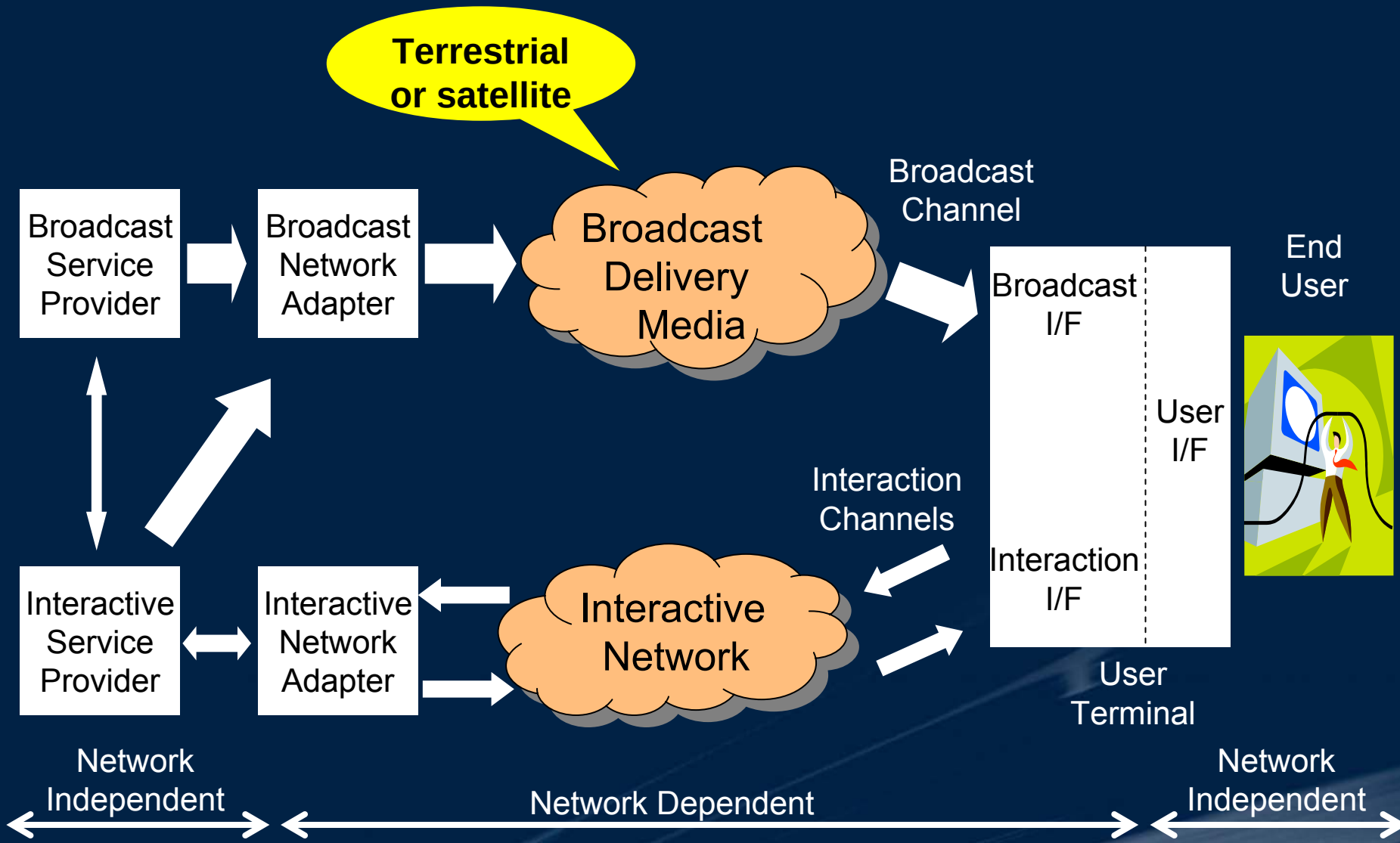
Outline

- Definition of wireless access and types of wireless access
- The origins of Fixed Wireless Access (FWA)
- Broadband Wireless Access (BWA)
- Radio Local Area Networks (RLANs)
- IMT-2000 – mobile and fixed, terrestrial and satellite
- Interactive broadcasting
- Convergence

Interactive Broadcasting Systems



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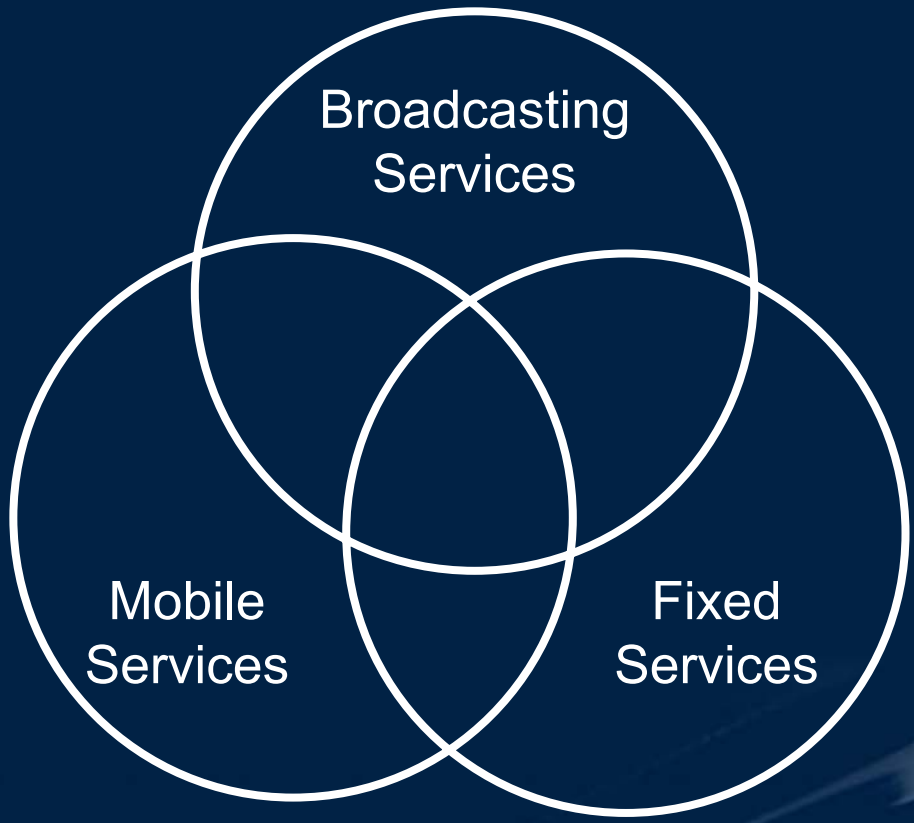
Convergence of Radiocommunication Services



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Terrestrial Wireless Interactive Multimedia Systems

Systems that operate in one or more of the Mobile, Fixed, and Broadcasting Services and are capable of supporting bi-directional exchange of information of more than one type (e.g. video, image, data, voice, sound, graphics) between users or between users and servers.

Typical technical characteristics of example systems

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System		Transmitted data rate	Typical frequency range
Cellular/MWA	Pre-IMT-2000 systems	14.4 kbit/s	0.8-2 GHz
	IMT-2000	2 Mbit/s (pico cells) 384 kbit/s (micro cells) 144 kbit/s (macro cells) enhancements up to 10 Mbit/s	0.8-2.7 GHz
	Systems beyond IMT-2000	Targets for research: 100 Mbit/s (high mobility) 1000 Mbit/s (low mobility)	(under study)
Intelligent Transportation Systems		Up to 54 Mbit/s	0.9-6 GHz
RLAN/wireless home networks		Up to 54 Mbit/s	0.9-6 GHz
FWA/BWA		56 kbit/s up to 312 Mbit/s	1 to 66 GHz
LMCS/LMDS/MMDS/MVDS/ MCS/MWS		up to 156 Mbit/s	2 to 6 GHz, above 20 GHz
Broadcasting	Sound (digital)	up to 1.843 Mbit/s (stationary) 1.152 Mbit/s (mobile)	0.54-1 500 MHz
	DTTB	up to 32 Mbit/s (stationary) 5 Mbit/s (mobile)	45-900 MHz

Summary

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- Have shown the basics of wireless access, including fixed, mobile and nomadic.
- Have shown the advantages of wireless access over wireline access under certain conditions of user density and mobility requirements.
- Have shown the standards and spectrum for RLANs and an example wireless mesh network application.
- Have shown the radio interfaces and basic technologies for IMT-2000 wireless access and the synergism of IMT-2000 with other radio systems.
- Have addressed the emerging convergence of wireless access systems, including terrestrial and satellite interactive broadcasting.

References

- **ITU World Radiocommunication Conference (WRC-03) Final Acts**
  http://www.itu.int/ITU-R/publications/acts/index.asp
- **ITU Radio Regulations, 2001**
  http://www.itu.int/ITU-R/publications/publication.asp?product=rr2001&lang=e
- **ITU-R Handbook on "Fixed Wireless Access", 2001**
  Hardcopy: http://www.itu.int/publications/scripts/shopcart/basket.php
  Softcopy: http://www.itu.int/itudoc/itu-r/bookshop/manuels/72419.html
- **ITU Handbook on "Deployment of IMT-2000 Systems", 2003**
  Hardcopy: http://www.itu.int/publications/docs/tsb/imt2000.html
  Softcopy: http://www.itu.int/itudoc/gs/imt2000/84207.html
- **ITU Internet Reports 2003: Birth of Broadband**
  http://www.itu.int/osg/spu/publications/sales/birthofbroadband/
- **ITU-R Wireless Access Systems Portal**
  http://www.itu.int/ITU-R/study-groups/was/index.html

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Fixed Wireless Access (FWA) systems: F-series Recommendations

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Rec. ITU-R	Title
F.757	Basic system requirements and performance objectives for fixed wireless access using mobile-derived technologies offering telephony and data communication services
F.1399	Vocabulary of terms for wireless access
F.1400	Performance and availability requirements and objectives for fixed wireless access to public switched telephone network
F.1401	Frequency bands for fixed wireless access systems and the identification methodology
F.1402	Frequency sharing criteria between a land mobile wireless access system and a fixed wireless access system using the same equipment type as the mobile wireless access system
F.1488	Frequency block arrangements for fixed wireless access (FWA) systems in the range 3 400-3 800 MHz
F.1489	A methodology for assessing the level of operational compatibility between fixed wireless access (FWA) and radiolocation systems when sharing the band 3.4-3.7 GHz
F.1490	Generic requirements for fixed wireless access (FWA) systems
F.1499	Radio transmission systems for fixed broadband wireless access (BWA) based on cable modem standards
F.1518	Spectrum requirement methodology when a fixed wireless access (FWA) system and a mobile wireless access (MWA) system using the same type of equipment coexist in the same frequency band
F.1613	Operational and deployment restrictions for FWA systems in Region 3 to ensure the protection of systems in the EES service (active) in the band 5 250-5 350 MHz

Mobile Wireless Access systems: M-series Recommendations

Rec. ITU-R	Title
M.622	Technical and operational characteristics of analogue cellular systems for public land mobile telephone use
M.1033	Technical and operational characteristics of cordless telephones and cordless telecommunication systems
M.1073	Digital cellular land mobile telecommunication systems
M.1457	Detailed specifications of the radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)

A complete list of ITU-R Recommendations on IMT-2000, including abstracts, can be found in:

ITU Handbook on "Deployment of IMT-2000 Systems", 2003
Hardcopy: http://www.itu.int/publications/docs/tsb/imt2000.html
Softcopy: http://www.itu.int/itudoc/gs/imt2000/84207.html

ITU-R Recommendations and Report on RLANs

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Rec. ITU-R	Title
M.1450	Characteristics of broadband RLANs
M.1454	E.i.r.p. density limit and operational restrictions for RLANs or other wireless access transmitters in order to ensure the protection of feeder links of NGSO systems in the MSS in the frequency band 5 150-5 250 MHz
M.1651	A method for assessing the required spectrum for broadband NWA systems including RLANs using the 5 GHz band
M.1652	Dynamic Frequency Selection (DFS) in Wireless Access Systems (WAS) including Radio Local Area Networks (RLAN) for the purpose of protecting the radiodetermination service in the 5 GHz band
M.1653	Operational and deployment requirements for WAS including RLANs in the MS to facilitate sharing between these systems and systems in the EESS (active) and the SRS (active) in the band 5 470-5 570 MHz within the 5 460–5 725 MHz range
F.1613	Operational and deployment restrictions for FWA systems in Region 3 to ensure the protection of systems in the EES service (active) in the band 5 250-5 350 MHz
SA.1632	Sharing in the band 5 250-5 350 MHz between the Earth exploration-satellite service (active) and wireless access systems (including radio local area networks) in the mobile service
Report ITU-R M.2034	Impact of radar detection requirements of dynamic frequency selection on 5 GHz wireless access system receivers

ITU-R Recommendations on Interactive Broadcasting

Rec. ITU-R	Title
BT.1369	Basic principles for a worldwide common family of systems for the provision of interactive television services
BT.1434	Network independent protocols for interactive systems
BT.1436	Transmission systems for interactive cable television services
BT.1667	Terrestrial return channel for interactive broadcasting services operating in the VHF/UHF broadcast band based on Recommendation ITU-R BT.1306
BO.1211	Digital multi-programme emission systems for television, sound and data services for satellites operating in the 11/12 GHz frequency range
BO.1516	Digital multiprogramme television systems for use by satellites operating in the 11/12 GHz frequency range
Document 6S/TEMP/22	Working Party 6S, PDNR on interactive satellite broadcasting systems (television, sound and data). Includes standards specified by ETSI EN 301 790 V1.3.1 and TIA-1008.

See also:
DTTB Handbook - Digital terrestrial television broadcasting in the VHF/UHF bands - Edition 2002 - V.01
Digital Radio Broadcasting Standard (EUREKA-147)
Digital Video Broadcasting Project (DVB)