Παρουσιάσεις για το Μάθημα Ασύρματων και Κινητών Τηλεπικοινωνιών του ΔΜΠΣ στο ΕΚΠΑ

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Απαιτήσεις μαθήματος

- **Δύο διδάσκοντες (Χ. Στελλάκης, Σ. Πασκαλής)**
- **Γραπτές εξετάσεις**
  - **Θέματα και από τους δύο διδάσκοντες**
  - **Συνολικός βαθμός >= 3,5**
- **Ομαδική εργασία**
  - **Ομάδες των 2-3 ατόμων**
  - **Τα θέματα προτείνονται από τους διδάσκοντες και τα επιλέγουν οι ομάδες, βάσει συνοπτικής πρότασης που υποβάλλουν**
  - **Κατ' εξαίρεση, ένα θέμα μπορεί να προταθεί από την ομάδα, αλλά θα πρέπει να συμφωνηθεί πρώτα με το Συντονιστή Διδάσκοντα**
  - **Παραδοτέα εργασίας: Η εργασία, παρουσίαση από όλους (20'), αρχείο παρουσίασης**
- **Συνολικός βαθμός >= 6,0**
  - **Μ.Ο. γραπτών και εργασίας**

Ύλη μαθήματος – Φάση Ι

- **Εισαγωγικές έννοιες στις ασύρματες επικοινωνίες**
- **Διάδοση ασύρματου σήματος**
  - **Φαινόμενα που τη διέπουν, Μοντελοποίηση διάδοσης, Κατάσταση multipath, Στατιστικές fading, Ανάλυση ισοζυγίου ζεύξης (Link Budget), Παράδειγμα σε σύστημα WCDMA**
- **Ασύρματη μετάδοση**
  - **Τεχνικές ασύρματης μετάδοσης (διαμόρφωση, ισοστάθμιση, Diversity, κωδικοποίηση καναλιού), Δείκτες απόδοσης μιας διαμόρφωσης, Παραδείγματα**
- **Ασύρματα δίκτυα κυψελοειδούς αρχιτεκτονικής**
  - **Σκοπιμότητα κυψελοειδών συστημάτων, περιγραφή, Επαναχρησιμοποίηση συχνότητας, Εγκυρότητα μεγέθους βασικής κυψέλης, Παρεμβολές και χωρητικότητα, Μηχανισμοί handoff, Εφαρμογή της θεωρίας ουρών στα ασύρματα δίκτυα, Τεχνικές βελτιστοποίησης της απόδοσης ενός δικτύου, Διαστασιολόγηση δικτύου, Παραδείγματα.**
- **Τεχνολογίες πολλαπλής πρόσβασης**
  - **FDMA, TDMA, CDMA, SDMA), Συστήματα 2ης και επόμενης γενεάς.**
- **Το πρότυπο GSM**
  - **Εισαγωγικά στοιχεία, Βασικές σχεδιαστικές αρχές, Υπηρεσίες, Αρχιτεκτονική, Περιγραφή των στοιχείων δικτύου, Η ραδιο-διεπαφή, Πρωτόκολλα, Φυσικά και λογικά κανάλια, Διαδικασίες σηματοδοσίας και παράδειγμα στη δημιουργία νέας σύνδεσης, Μεταπήδηση συχνοτήτων**
- **Συστήματα CDMA**
  - **Βασικοί δείκτες απόδοσης δικτύου, Εξάπλωση (spreading) σήματος, Κέρδος εξάπλωσης, Μηχανισμός handoff, Macro / micro diversity, Στατιστικές handoff, Στοιχεία καναλιών και ομαδοποίηση (pooling), Κυρίαρχος εξυπηρετητής, Έλεγχος ισχύος, Κάλυψη συστήματος, Μεταβλητότητα μεγέθους κυψέλης, Χωρητικότητα δικτύου, Φόρτος δικτύου, Επαναχρησιμοποίηση συχνότητας, Απόδοση δικτύου, Εξισορρόπηση απόδοσης, Παραδείγματα.**

PART I

Introduction to Wireless Communications

What is Wireless?

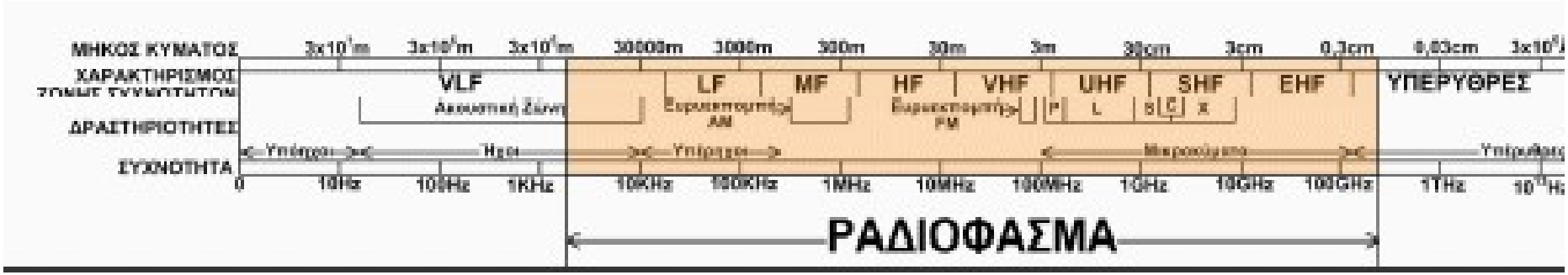
Wireless operations permits services, such as long range communications, that are either:

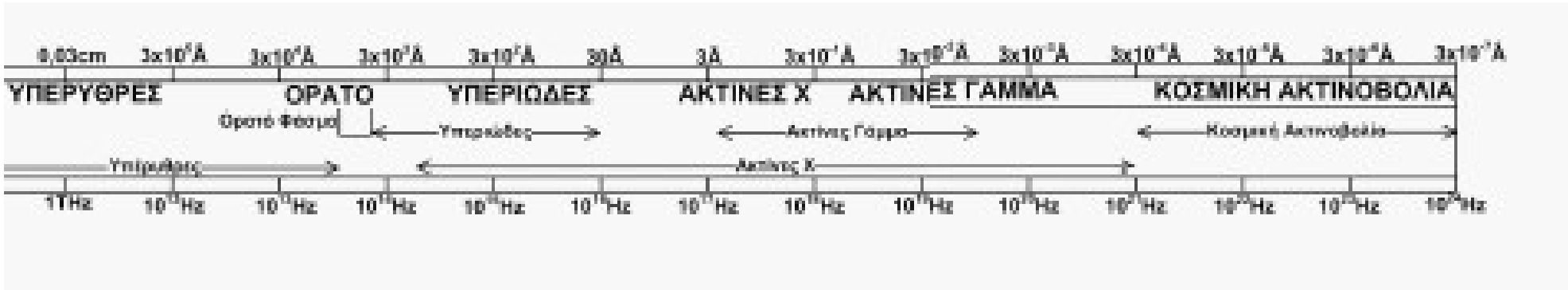
- impossible or
- impractical or
- Less time efficient or
- More costly

to implement with the use of wires.

The term “wireless” is commonly used in the telecommunications industry to refer to telecommunications systems (e.g. radio transmitters and receivers, remote controls, computer networks, network terminals, etc.) which use some form of energy (e.g. radio frequency, infrared light, laser light, visible light, acoustic energy, etc.) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances.

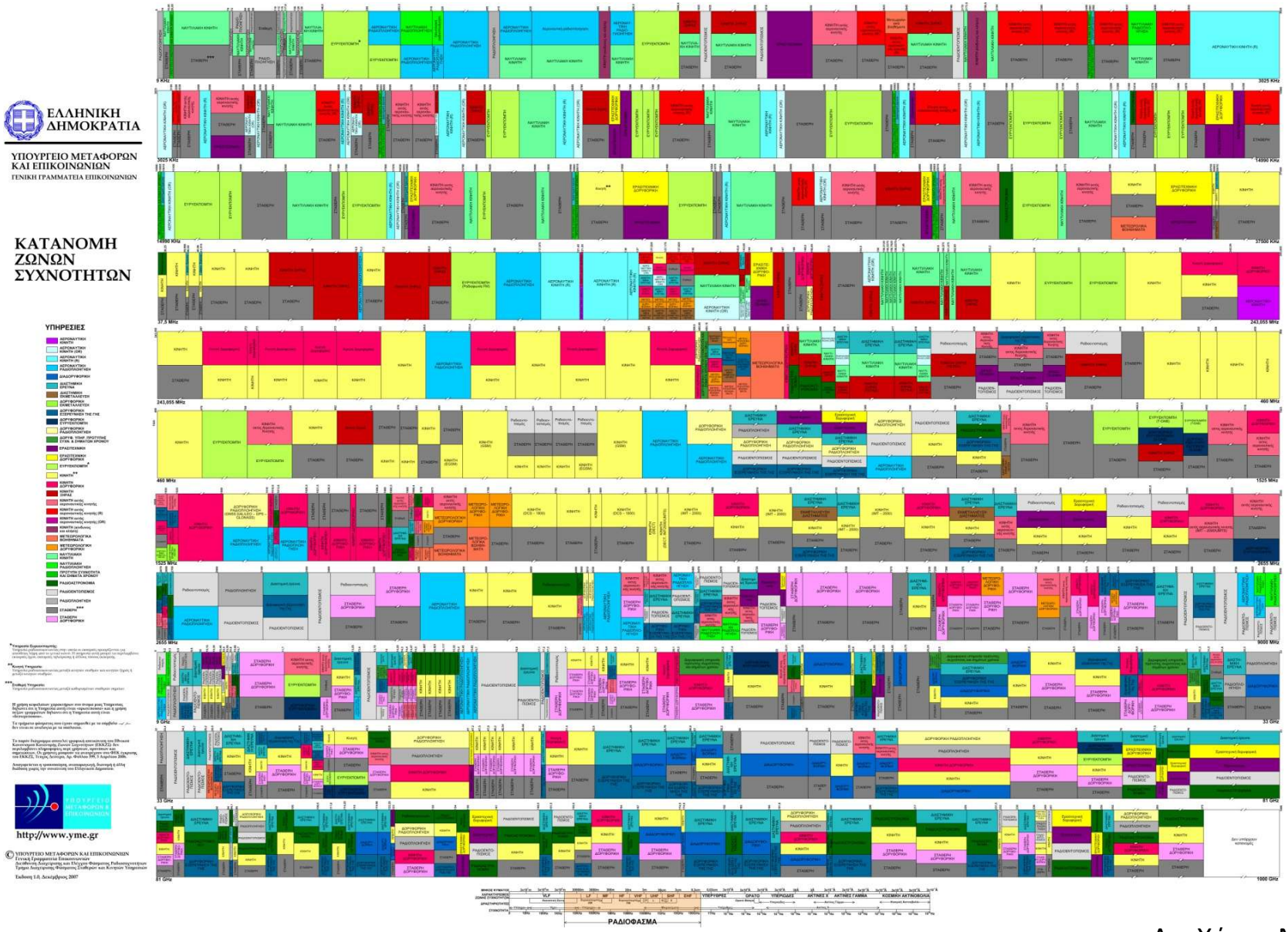
Spectrum: The fundamental resource



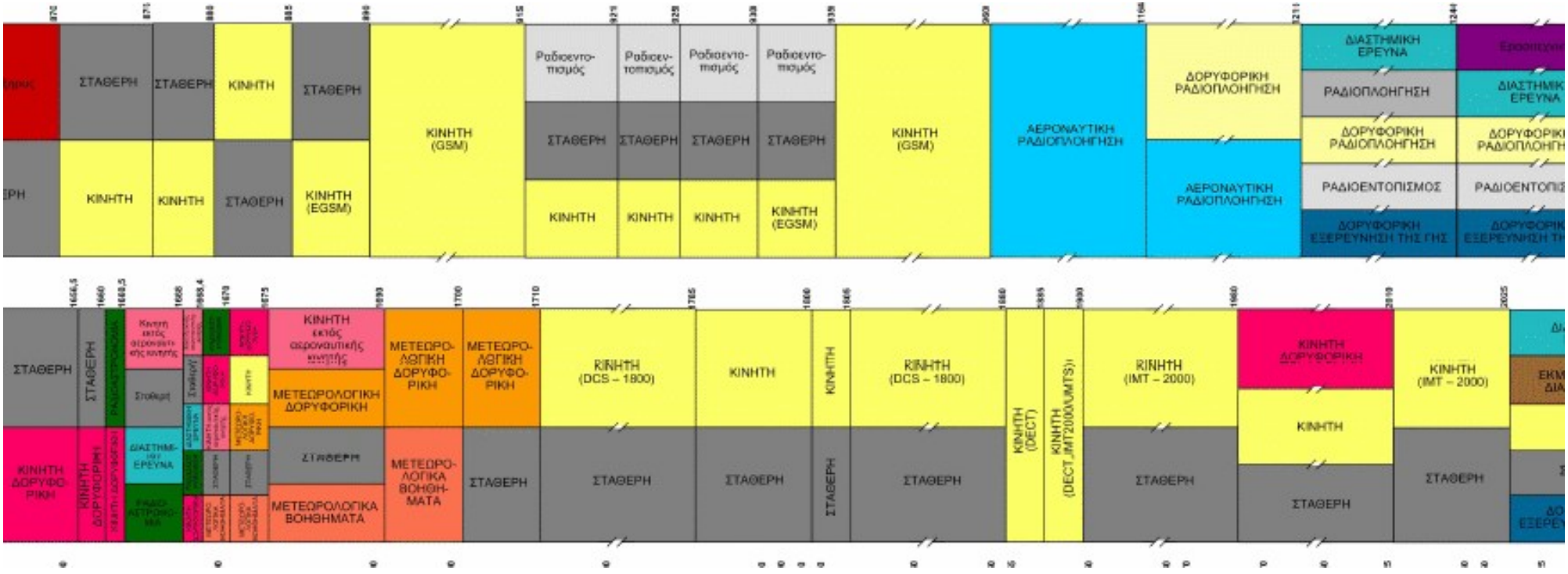


http://www.yme.gr

National Spectrum Map



Spectrum allocation at Cellular band



Wireless Technologies Timeline

Table 1.1 A simple timeline in Wireless Technologies evolution (this is not to be considered an 'all inclusive' timeline)

1896	Guglielmo Marconi develops the first wireless telegraph system
1927	First commercial radiotelephone service operated between Britain and the US
1946	First car-based mobile telephone set up in St. Louis, using 'push-to-talk' technology
1948	Claude Shannon publishes two benchmark papers on Information Theory, containing the basis for data compression (source encoding) and error detection and correction (channel encoding)
1950	TD-2, the first terrestrial microwave telecommunication system, installed to support 2400 telephone circuits
1950s	Late in the decade, several 'push-to-talk' mobile systems established in big cities for CB-radio, taxis, police, etc.
1950s	Late in the decade, the first paging access control equipment (PACE) paging systems established
1960s	Early in the decade, the Improved Mobile Telephone System (IMTS) developed with simultaneous transmit and receive, more channels, and greater power
1962	The first communication satellite, Telstar, launched into orbit
1964	The International Telecommunications Satellite Consortium (INTELSAT) established, and in 1965 launches the Early Bird geostationary satellite
1968	Defense Advanced Research Projects Agency – US (DARPA) selected BBN to develop the Advanced Research Projects Agency Network (ARPANET), the father of the modern Internet
1970s	Packet switching emerges as an efficient means of data communications, with the X.25 standard emerging late in the decade

Table 1.1 (*continued*)

1977	The Advanced Mobile Phone System (AMPS), invented by Bell Labs, first installed in the US with geographic regions divided into 'cells' (i.e. cellular telephone)
1983	January 1, TCP/IP selected as the official protocol for the ARPANET, leading to rapid growth
1990	Motorola files FCC application for permission to launch 77 (revised down to 66) low earth orbit communication satellites, known as the Iridium System (element 77 is Iridium)
1992	One-millionth host connected to the Internet, with the size now approximately doubling every year
1993	Internet Protocol version 4 (IPv4) established for reliable transmission over the Internet in conjunction with the Transport Control Protocol (TCP)
1994–5	FCC licenses the Personal Communication Services (PCS) spectrum (1.7 to 2.3 GHz) for $7.7 billion
1998	Ericsson, IBM, Intel, Nokia, and Toshiba announce they will join to develop Bluetooth for wireless data exchange between handheld computers or cellular phones and stationary computers
1990s	Late in the decade, Virtual Private Networks (VPNs) based on the Layer 2 Tunneling Protocol (L2TP) and IPSEC security techniques become available
2000	802.11(b)-based networks are in popular demand
2000–1	Wired Equivalent Privacy (WEP) Security is broken. The search for greater security for 802.11(x)-based networks increases

Evolution of Mobile Radio Communications

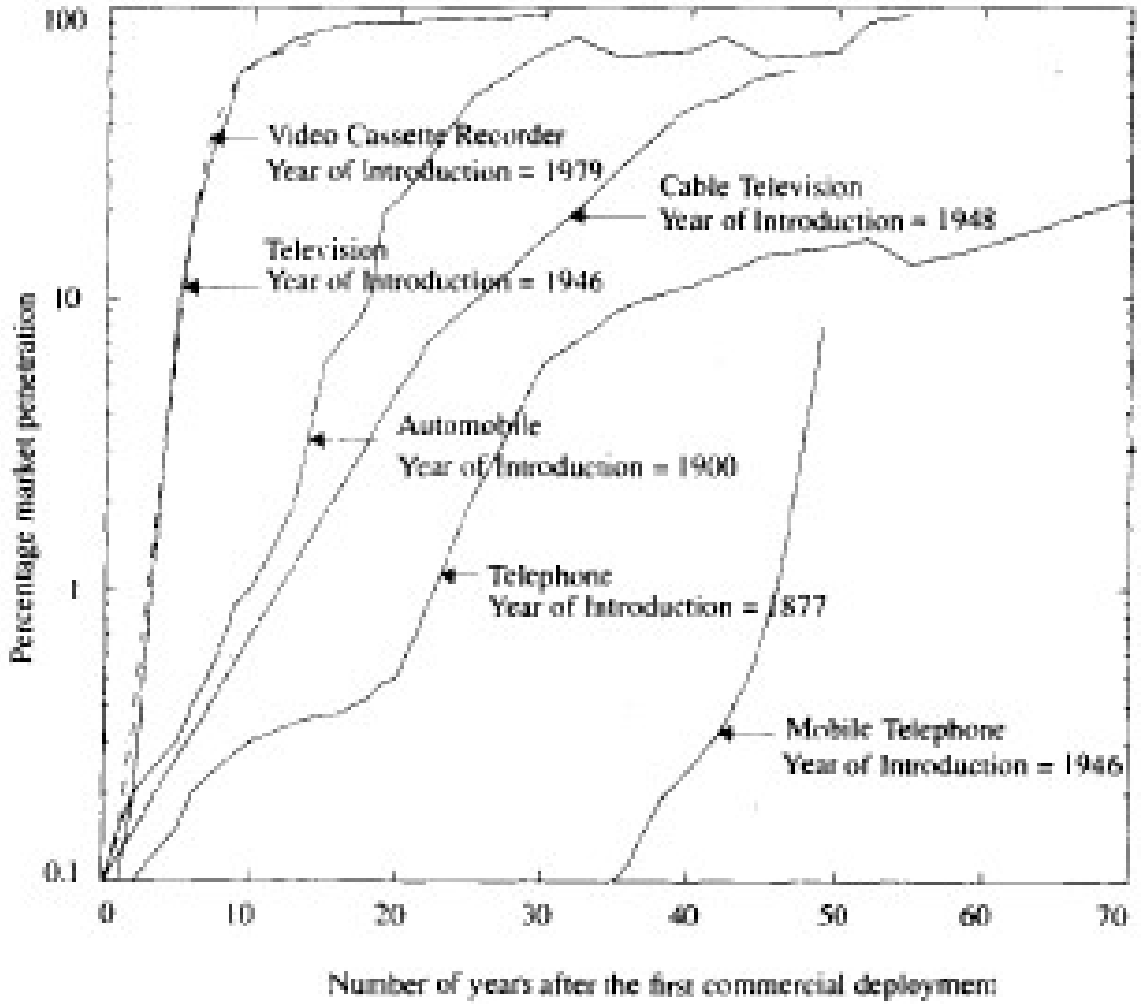
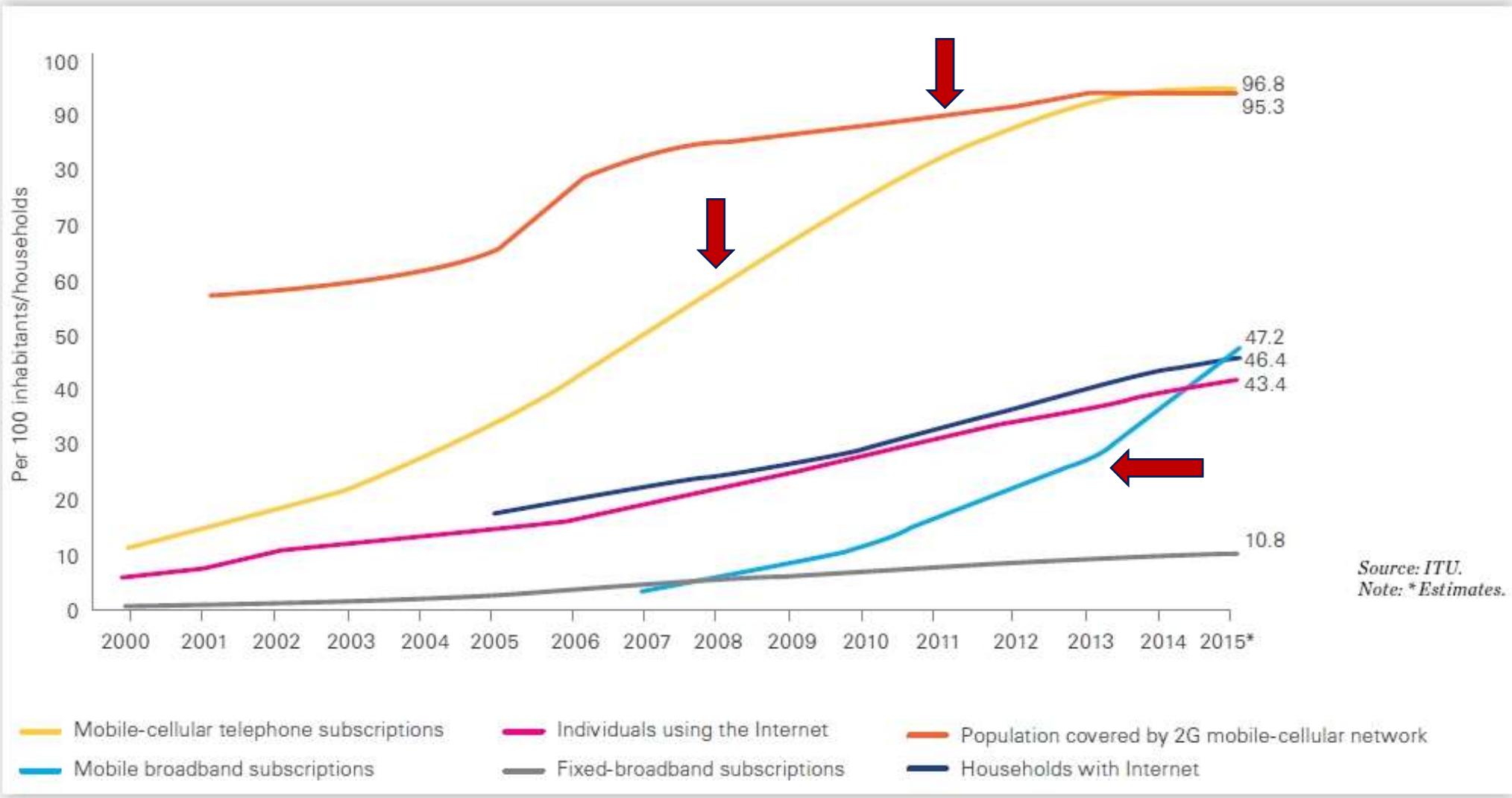


Figure 1.1
Figure illustrating the growth of mobile telephony as compared to other popular inventions of this century.

Evolution of ICT



Typical System Definitions

Term	Description
Base Station (BS)	A fixed station in a mobile radio system used for radio communication with mobile stations. Base stations are located at the center or on the edge of a coverage region and consist of radio channels and transmitter and receiver antennas mounted on a tower
Mobile Station (MS)	A station in the mobile radio service intended for use while in motion at unspecified locations. MS's may be hand-held personal units (portables) or installed on vehicles (vehicular mobiles)
Transceiver	A device capable of simultaneously transmitting (Tx) and receiving (Rx) radio signals
Subscriber	A user who pays subscription charges for using a mobile communications system
Roamer	An MS which operates in a service area (market) other than that from which service has been subscribed

Typical System Definitions – cont'd

Term	Description
Forward (or Downlink) Channel	Radio channel used for transmission of information from the BS to MS
Reverse (or Uplink) Channel	Radio channel used for transmission of information from the MS to BS
Control Channel	Radio channels used for transmission of call setup, call request, call initiation, and other beacon or control purposes
Mobile Switching Center (MSC) or Mobile Telephone Switching Office (MTSO)	Switching center which coordinates the routing of calls in a large service area. In a cellular radio system, an MSC connects various BS's and MS's to the Public Switch Telephone Network (PSTN)
Page	A brief message which is broadcast over the entire service area, usually in a simulcast fashion by many BS's at the same time

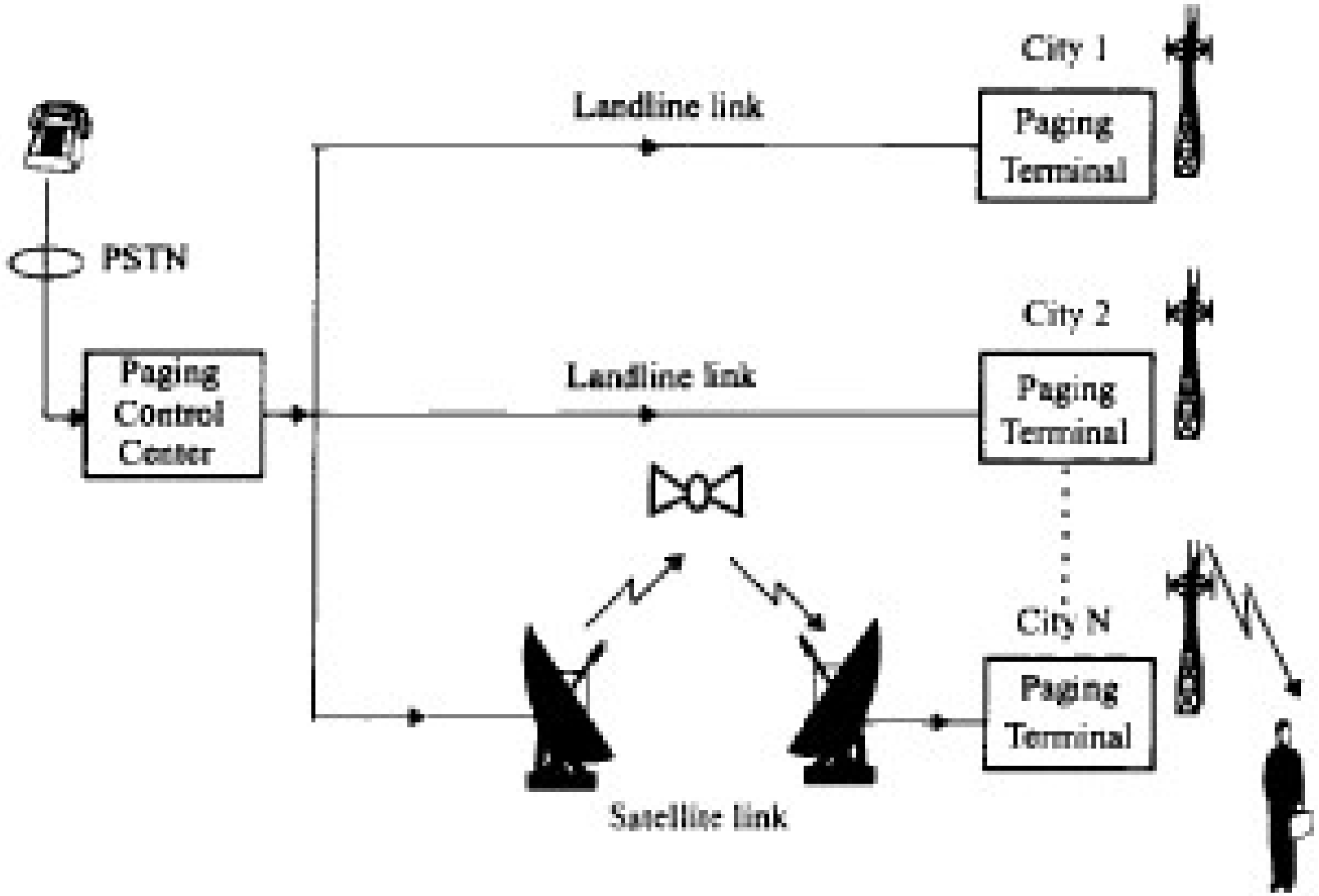
Typical System Definitions – cont'd

Term	Description
Handoff or Handover	The process of transferring the service provided to an MS from one channel or BS to another
Simplex Systems	Communication systems which provide only 1-way communication (ex. Paging Systems: Messages are received but not acknowledged)
Half Duplex Systems	Communication systems which allow 2-way communication by using the same radio channel for both transmission and reception. At any given time, the user can only either transmit or receive information. Typical Operational Constraints: • Push-to-talk • Release-to-listen

Typical System Definitions – cont'd

Term	Description
Full Duplex Systems	Communication systems which allow simultaneous 2-way communication. Transmission and reception is typically on: • two different frequency channels, (FDD), or • using different time slots (TDD)
Frequency Division Duplexing (FDD)	Simultaneous radio transmission channels for the MS and the BS, so that they both can constantly transmit while simultaneously receiving signals from one another. • At the BS, separate Tx and Rx antennas are used • At the MS, a common antenna is used, and a "duplexer" is used inside the MS, to enable the simultaneous Tx and Rx
Time Division	A common radio channel is used and at a portion of

A typical wide-area Paging System



A typical Cordless Telephone System

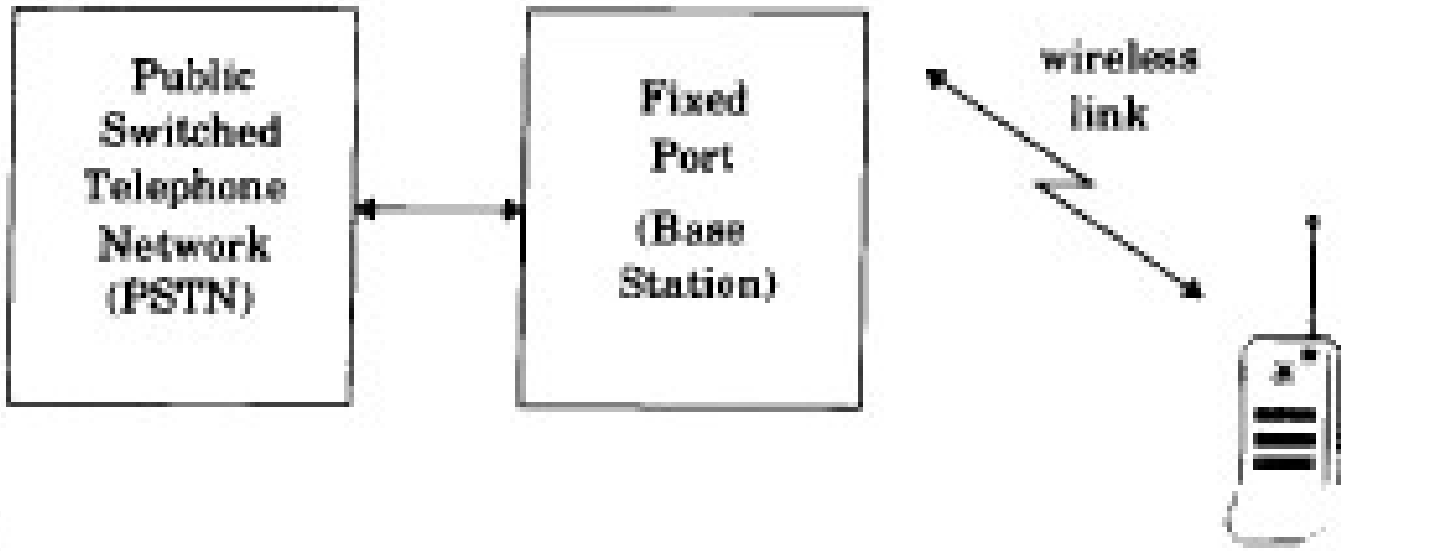
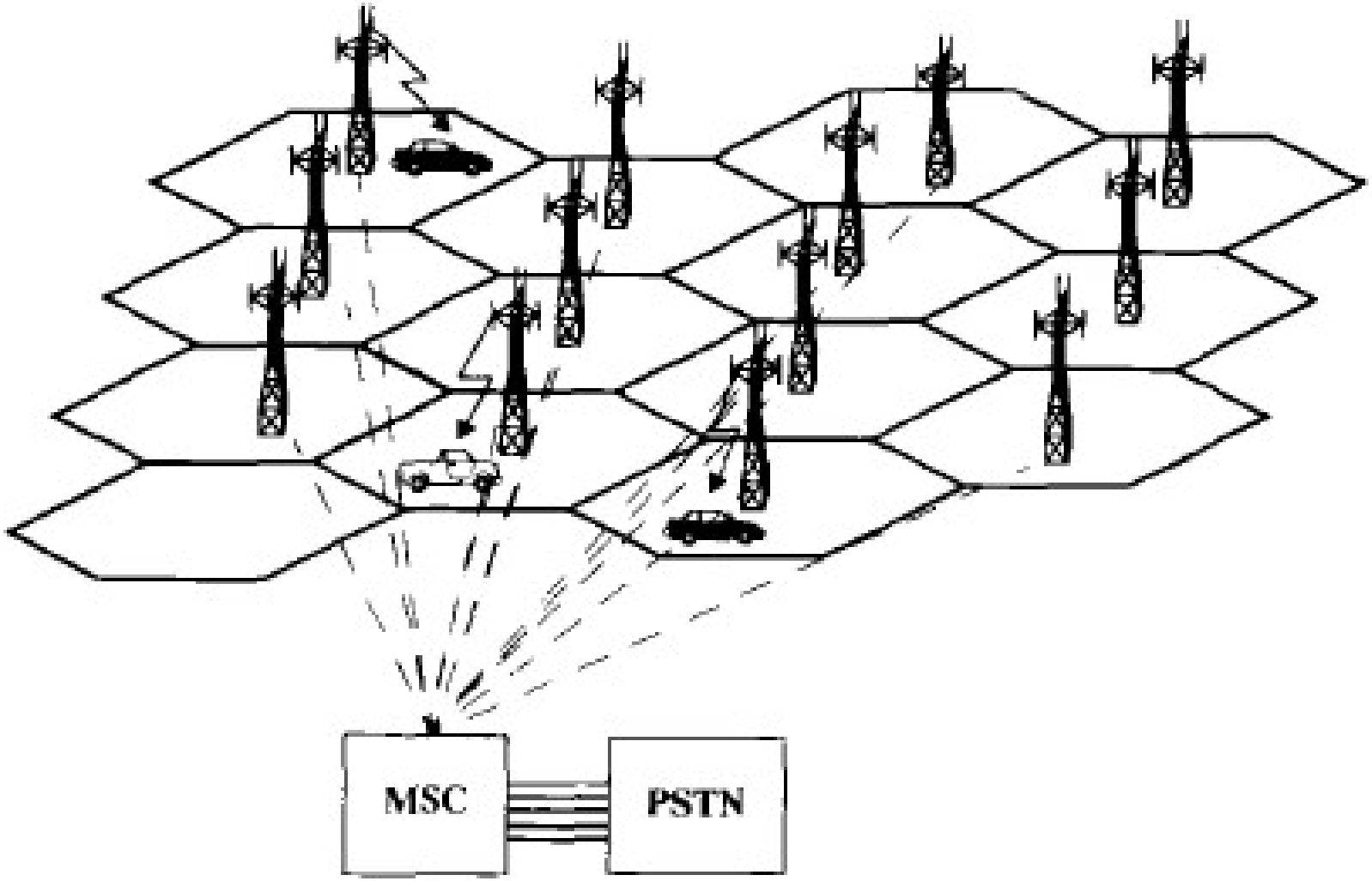


Figure 1.4
Diagram of a cordless telephone system.

A typical Mobile (cellular architecture) System



Making a call through a cellular network

- **Communication between the MS's and the BS's is defined by a standard *Common Air Interface (CAI)* that specifies four different radio channels**
  - ***Forward Voice Channels (FVC)* are used for voice Tx from the BS to MS**
  - ***Reverse Voice Channels (RVC)* are used for voice Tx from the MS to BS**
  - ***Control Channels (FCC or RCC)* are responsible for transmitting and receiving data messages that carry call initiation and all other service management requests (usually 5% of the total channels available in the system, while the remaining 95% is allocated to voice and data traffic)**
- **When an MS is turned on and is not engaged in a call, it scans all FCC's to determine the strongest; it then considers the corresponding BS as the *Primary Server***
- **A similar search is conducted when the strongest FCC drops below a pre-specified level**

Making a call through a cellular network – cont'd

- **When a call is placed to an MS,**
  - **The MSC dispatches the request to all BS's of the network**
  - **The *Mobile Identification Number* is broadcast as a message over all the FCC's**
  - **The MS receives the message, identifies itself and responds back through the RCC**
  - **The BS relays the acknowledgement sent by the MS and informs the MSC of the handshake**
  - **Then, the MSC instructs the BS to move the call to an used voice channel of the cell**
  - **The BS signals the MS to change frequencies to an unused pair {FVC, RVC}**
  - **Next, another *alert message* is transmitted over the FVC to instruct the mobile device to ring, thereby instructing the user to answer the phone.**

Making a call through a cellular network – cont'd

- **During the call,**
  - **The MSC adjusts the Tx power of the MS and changes the channels of the MS or the BS, in order to maintain acceptable call quality**
  - **Special control signaling is applied to the voice channels, so that the MS remains under control by the serving BS and MSC.**
  - **As the subscriber moves in and out of the range of each BS, control signaling is applied to change the serving BS / MSC *(Handoff)***
- **When the MS originates the call,**
  - **A call initiation request is sent through the RCC**
  - **The MS transmits its *MIN, Electronic Serial Number (ESN)* , the *telephone number* of the called party plus some other information, such as its max Tx power level.**
  - **The BS receives the data and sends it to the MSC**
  - **The MSC validates the request, makes connection to the called party through the PSTN and instructs the BS and MS to move to an unused pair of voice channels**

Comparison of Mobile Systems – Mobile Station

Service	Coverage Range	Required Infra-structure	Complexity	Hardware Cost	Carrier Frequency	Functionality
TV Remote Control	Low	Low	Low	Low	Infra-red	Transmitter
Garage Door Opener	Low	Low	Low	Low	< 100 MHz	Transmitter
Paging System	High	High	Low	Low	< 1 GHz	Receiver
Cordless Phone	Low	Low	Moderate	Low	< 100 MHz	Transceiver
Cellular Phone	High	High	High	Moderate	< 1 GHz	Transceiver

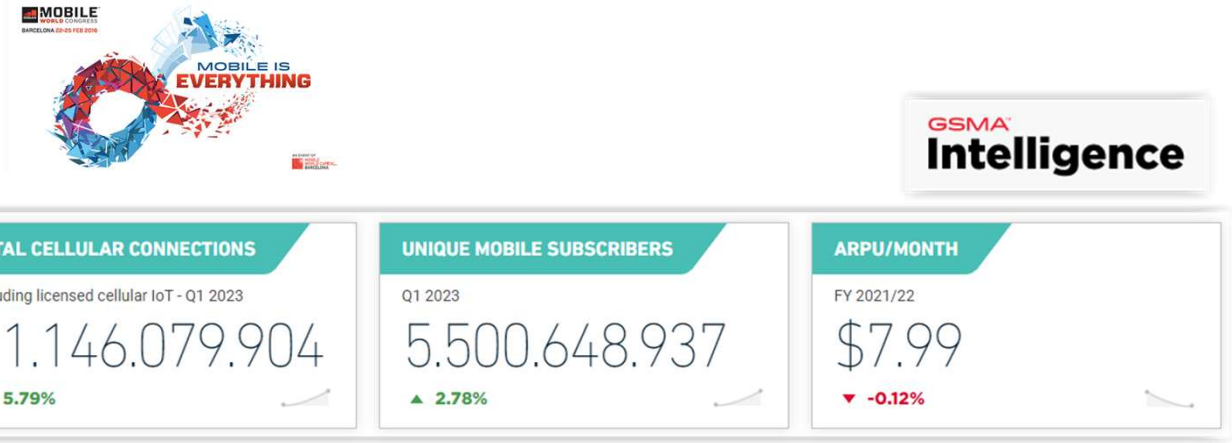
Comparison of Mobile Systems – Base Station

Service	Coverage Range	Required Infra-structure	Complexity	Hardware Cost	Carrier Frequency	Functionality
TV Remote Control	Low	Low	Low	Low	Infra-red	Receiver
Garage Door Opener	Low	Low	Low	Low	< 100 MHz	Receiver
Paging System	High	High	High	High	< 1 GHz	Transmitter
Cordless Phone	Low	Low	Low	Moderate	< 100 MHz	Transceiver
Cellular Phone	High	High	High	High	< 1 GHz	Transceiver

The Road Ahead

- **The explosive growth of internet-based applications (ex. Location based services, social networks, etc.)**
- **In addition to the demand for providing novel and ubiquitous personal communication services to citizens, wherever they are**
- **In addition to the need for rapidly deploying sophisticated telephone networks in emerging markets, where landline telephone coverage is nearly non-existent or obsolete**

Makes wireless communications business very important for today's and tomorrow's socio-economic development



Some Useful Links

- Υπουργείο Υποδομών, Μεταφορών και Δικτύων (www.yme.gov.gr)
- Εθνική Επιτροπή Τηλεπικοινωνιών και Ταχυδρομείων (www.eett.gr)
- Εθνικό Συμβούλιο Ραδιοτηλεόρασης (www.esr.gr)
- Ένωση Εταιρειών Κινητής Τηλεφωνίας (www.eekt.gr)
- International Telecommunications Union (www.itu.int)
- Digital Agenda for Europe – Wireless (www.https://ec.europa.eu/digital-agenda/en/newsroom/reports-and-studies/wireless-Europe)
- GSM Association (www.gsma.com)
- 3rd Generation Partnership Project (www.3gpp.org)
- Telecommunications Industry Association (www.tiaonline.org)
- IEEE Wireless Communications Society (www.comsoc.org/wirelessmag)
- IEEE standards (http://standards.ieee.org)
- Federal Communications Commission (USA) (www.fcc.gov)
- Mobile World Congress (www.mobileworldcongress.com)
- GSM Portal (www.gsmarena.com)
- Wikipedia (https://en.wikipedia.org/wiki/Wikipedia)

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