

4TC-Architectures de Réseaux Mobiles Mobile Network Architectures

Part 1 – General Introduction

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General Outline

| Course structure

- | 12x2h – lectures: Razvan Stanica, Fabrice Valois, Alberto Conte (Alcatel-Lucent)
- | 3x2h – TD: Razvan Stanica, Fabrice Valois
- | 3x4h – TP: Razvan Stanica, Fabrice Valois, Diala Naboulsi

| Grading system

- | Written exam, all documents authorized
- | Tests on moodle before classes 3, 4, 5, 7 and 10 (only negative points)
- | 4TC-ARM is part of the UE TTC and represents 2 ECTS

General Outline

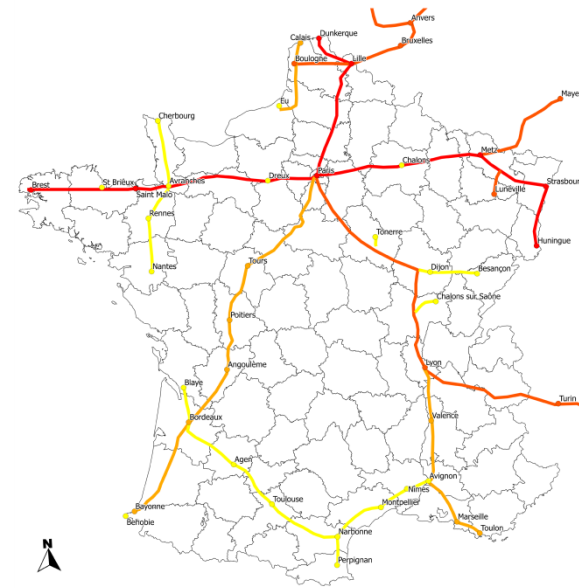
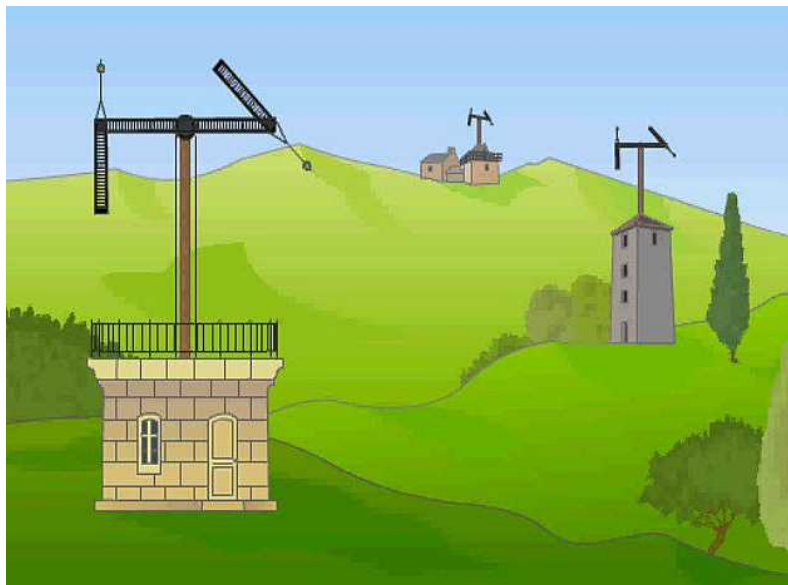
- | Course structure

- | 4 lectures on transversal topics: basic cellular concepts, network architecture, mobility, logical channels, protocols
- | 3 lectures on GSM
- | 2 lectures on UMTS
- | 3 lectures on LTE

A little bit of history

Wireless communication systems

- Actually predate wired systems: Greek hydraulic telegraph, drums, smoke, heliographs
- First known large scale system: the Chappe network



Le réseau Chappe en France

Directions (date de création)

- 1793-1800
- 1800-1815
- 1815-1830
- Après 1830

Lignes (date de création)

- 1793-1800
- 1800-1815
- 1815-1830
- Après 1830

A little bit of history

- | Use of electromagnetic waves
 - | 1832 - James Lindsay: wireless transmission through conductive water
 - | 1880 - Alexander Bell and Charles Tainter: audio conversation over modulated light beams (photophone)
 - | 1888 - Heinrich Hertz: experimental proof of the existence of electromagnetic waves (predicted by James Maxwell and Michael Faraday)
 - | 1901 - Guglielmo Marconi: first radio communication, between Canada and England

A little bit of history

- | The beginnings of mobile radio
 - | World War I: wireless telephony on military trains between Berlin and Zossen
 - | 1921 – Detroit police: first wireless dispatch system
 - | 1926: phone service for 1st class travelers on German trains
 - | World War II: use of hand-held radio transceivers (walkie-talkie) and mobile telephone available in cars
 - | 1946 - first public mobile phone service: Mobile Telephone Service (MTS), commercialized by AT&T in Saint Louis

A little bit of history

┆ MTS

- ┆ Use of the VHF band (30-300 MHz)
- ┆ Push to talk
- ┆ Operator assisted
- ┆ Subscriber equipment weight: 36kg
- ┆ Connection with the Public Switched Telephone Network (PSTN)
- ┆ Three customers in the city could call at the same time
- ┆ Equivalent networks followed in other countries: A-Netz in Germany, OLT in Norway
- ┆ Evolutions: Improved MTS (IMTS), Radio Common Carrier (RCC)
- ┆ In France, an equivalent network launched in 1956 (500 users in 1973)

Going cellular

| Cellular

- | 1967 - Richard Frenkiel, Joel Engel, Philip Porter (Bell Labs): design of the first cellular system
- | 1973: First hand-held mobile phone
- | 1979 – NTT, Japan – Deployment of the first cellular phone system
- | 1981 – NMT, Northern Europe: First European cellular network
- | 1983 – USA: Advanced Mobile Phone System (AMPS)

Going cellular

1G

- | French equivalent: Radiocom 2000
- | Launched in 1986 by France Telecom
- | A concurrent network, NMT-F, launched by SFR in 1989
- | Works in the 400 MHz band
- | Analog voice transmission
- | Digital signaling traffic
- | No hand-over initially (feature added after a few years)
- | 60k users in 1988, with 90% of devices installed in cars
- | No encryption mechanism
- | Easy cell phone cloning
- | Use of Frequency Division Multiple Access (FDMA)

Going cellular

| 2G

- | 1991: First deployment by Radiolinja in Finland
- | Digital voice transmissions
- | Security mechanisms
- | Introduction of the Short Message Service (SMS)
- | User identification based on the Subscriber Identification Module (SIM) card
- | Uses frequencies around 900 MHz and 1.8 GHz
- | Distinction between uplink and downlink

Going cellular

| 2G

- | Several technologies proposed, with different types of multiplexing
- | Global System for Mobile Communications (GSM) – Time Division Multiple Access (TDMA): 80% of subscribers worldwide
- | Initial Standard 95 (IS-95) – Code Division Multiple Access (CDMA): 17% of subscribers worldwide, mainly in Americas and Asia
- | Evolutions added data transmission capacities
- | General Packet Radio Service (GPRS) – 2.5G: up to 40kb/s
- | Enhanced Data Rates for GSM Evolution (EDGE) – 2.75G: up to 500kb/s

Going cellular

| 3G

- | 2001: First deployment by NTT DoCoMo in Japan
- | Mobile broadband data
- | Data rate of up to 3Mb/s
- | Decreased connection establishment time
- | Quality of Service differentiation
- | New services available: VoIP, Mobile TV, location based services
- | New types of devices appear: e-readers, smartphones, tablets

Going cellular

- | 3G
 - | Generalization of CDMA
 - | Competing technologies promoted in different regions
 - | Universal Mobile Telecommunications System (UMTS): Europe, Japan, China
 - | CDMA2000: North America and South Korea, with the possibility of sharing the same infrastructure as IS-95 networks
 - | Evolutions known under the name of High Speed Packet Access (HSPA), and can provide data rates up to 42Mb/s downlink and 7Mb/s uplink

Going cellular

- | 4G
 - | Native IP networks
 - | Scalable channel bandwidth
 - | Use of Orthogonal Frequency Division Multiple Access (OFDMA)
 - | Advanced antenna systems
 - | Allow handovers between heterogeneous technologies
 - | Theoretical data rates of 1GB/s in static environments and 100Mb/s in high mobility

Going cellular

- | 4G
 - | Two competing technologies on the market, which do not respect the data rate requirements (sometimes described as 3.9G)
 - | Up to 100 Mb/s in the downlink
 - | Worldwide Interoperability for Microwave Access (WiMAX), first deployed in 2006 in South Korea
 - | Long Term Evolution (LTE), first deployed in 2009 in Sweden and Norway
 - | First technology expected to be 4G compliant: LTE Advanced (LTE-A), currently under deployment

Other technologies

| Satellite phone

- | Uses orbiting satellites instead of terrestrial base stations
- | Requires a constellation of satellites to maintain connectivity
- | Several systems launched at the end of the '90s: Iridium, Globalstar, Orbcomm
- | Expensive deployment and maintenance, all these companies filed for bankruptcy
- | The restructured Iridium Communications has more than 600k users

Other technologies

┆ Cordless phones

┆ CT2 technology

┆ A mobile device and a home base station, connected to the landline network

┆ Voice and data transmission

┆ Calls can be made, but not received, through public base stations

┆ In France, Bi-Bop network launched in 1991 in Paris, Lille and Strasbourg

┆ A peak of 300k users

┆ Bi-Bop network closed in 1997

Other technologies

| Cordless phones

- | Digital Enhanced Cordless Telecommunications (DECT)
- | First generation launched in Europe in 1987
- | Private indoor digital network, for high density environments
- | Direct connection to landline networks
- | Up to 500m range
- | TDMA based
- | Intra-technology hand-over
- | Inter-technology hand-over with GSM defined (but no known implementation)

Other technologies

| Public safety networks

- | Terrestrial Trunked Radio (TETRA)
- | Used by government agencies, emergency services, military
- | Long range, high reliability
- | Use of a base station or direct communication between devices in walkie-talkie mode
- | User devices can act as relays
- | One-to-one, one-to-many and many-to-many voice and data communication
- | Highly secured communications
- | Low data throughput

Other technologies

- | Local area networks

- | Wi-Fi

- | Technology coming from the computer communication world

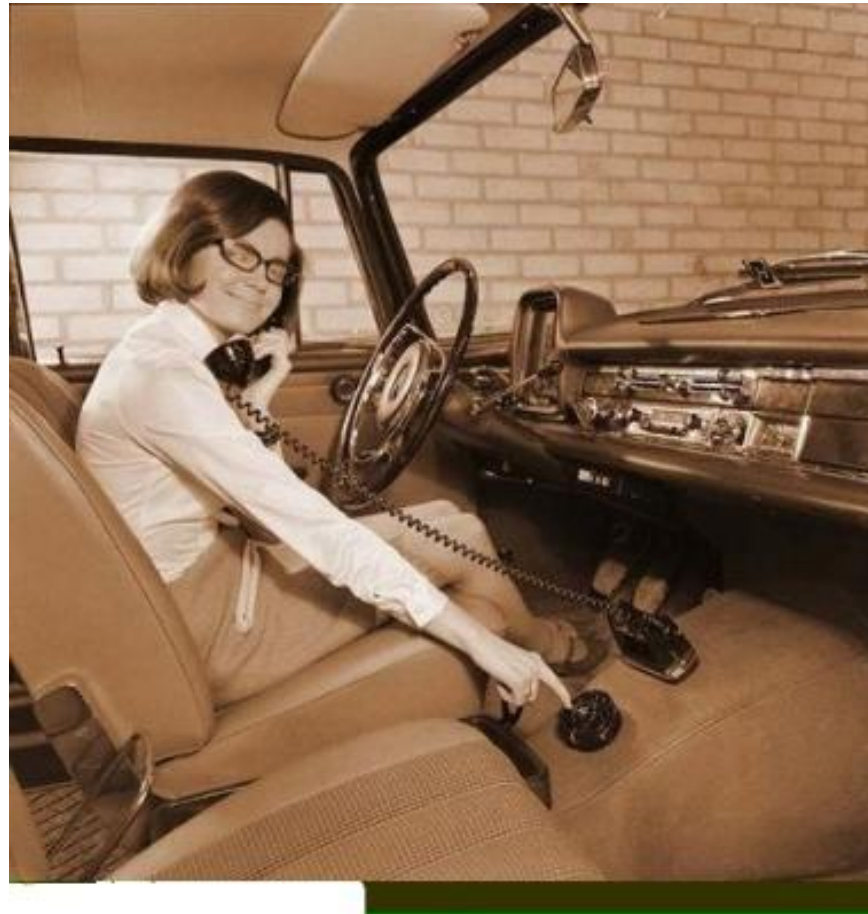
- | Dominant technology on the market

- | Convergence with cellular networks

- | Integration in 5G networks?

Embedded computing evolution

MTS car phone



Embedded computing evolution

- | First mobile phone – Motorola 1973



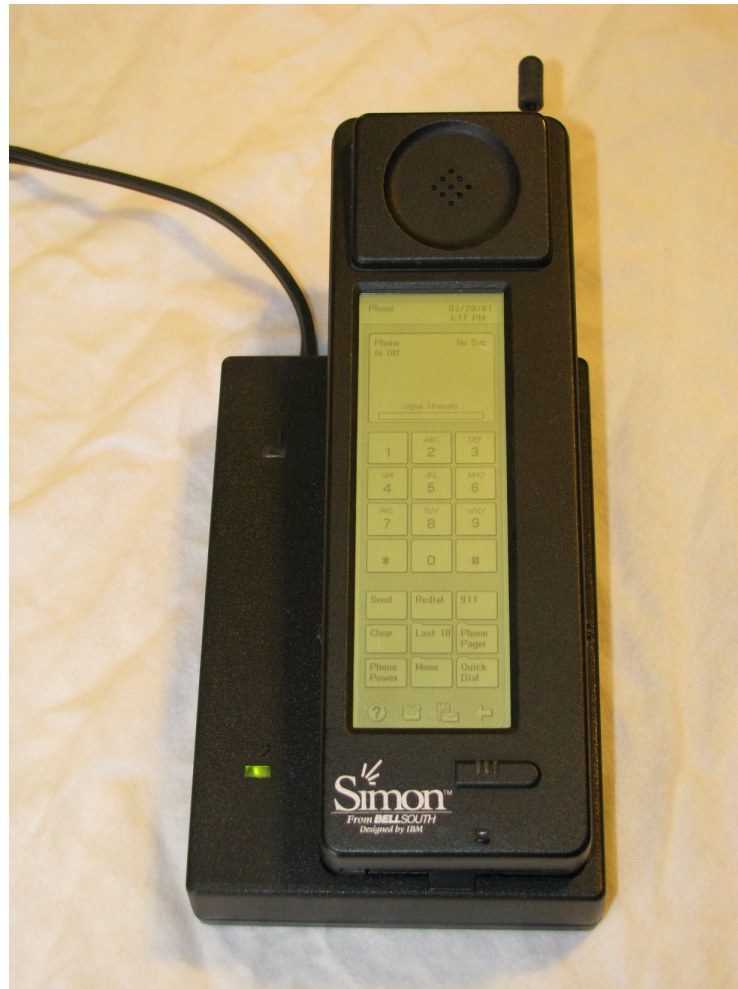
Embedded computing evolution

Cell phone evolution



Embedded computing evolution

- First smartphone: IBM Simon (1994)



Standardization

- | International Telecommunication Union (ITU)
 - | Based in Geneva, Switzerland
 - | Formed in 1865, a United Nations agency since 1947
 - | Issues requirements regarding mobile phone systems
 - | International Mobile Telecommunications (IMT-2000): requirements for 3G systems
 - | IMT Advanced: requirements for 4G systems, released in 2008
 - | Working Party 5D, to study IMT vision for 2020 and beyond, launched in 2013

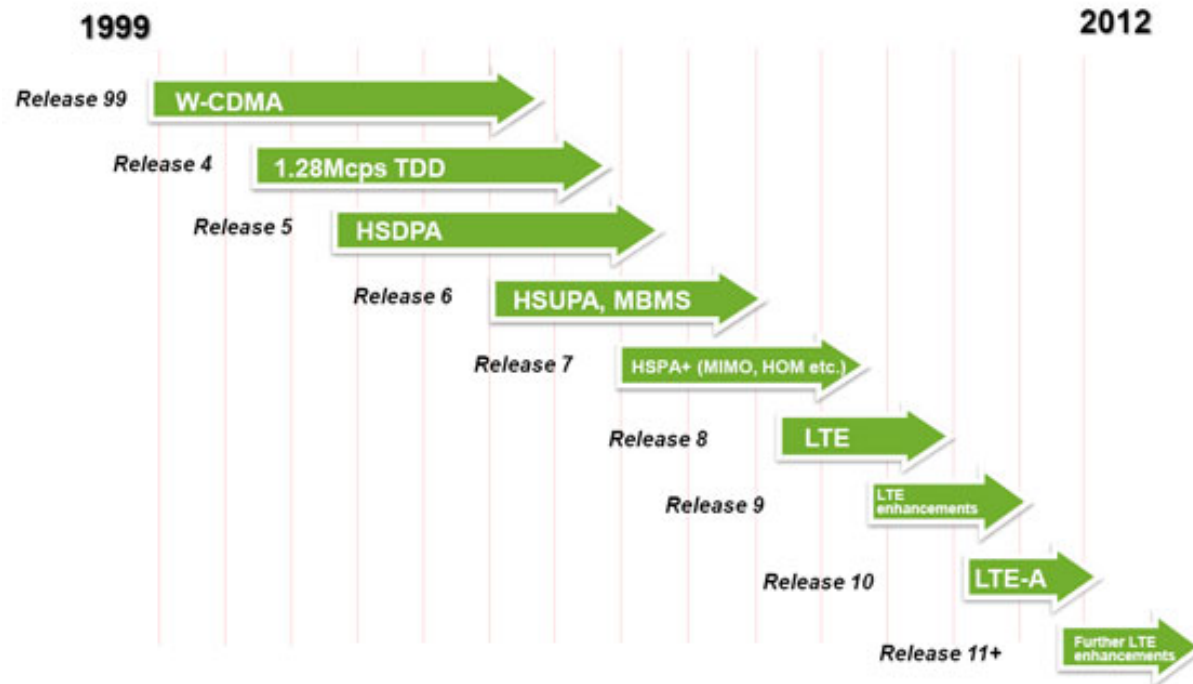
Standardization

- | European Telecommunications Standards Institute (ETSI)
 - | Based in Sophia Antipolis, France
 - | Created in 1988, and recognized by the European Commission
 - | Full members from EU member countries, associate members from outside countries
 - | Structured in working groups
 - | Delivers standards, technical specifications and technical reports
 - | Authored and maintained the GSM standard since the late '80s

Standardization

3rd Generation Partnership Project (3GPP)

- A collaboration between groups of telecommunication associations
- Members: ETSI, ARIB and TTC (Japan), ATIS (USA), CCSA (China), TTA (South Korea)
- In charge of GSM evolutions: GPRS, EDGE, UMTS, HSxPA, LTE
- Periodically publishes “releases”



Standardization

- | 3rd Generation Partnership Project 2 (3GPP2)
 - | Another collaboration between groups of telecommunication associations
 - | Members: ARIB and TTC (Japan), ATIS (USA), CCSA (China), TTA (South Korea) – same as in 3GPP, with the exception of ETSI
 - | In charge of CDMA2000 standard for 3G networks

Standardization

- | Institute of Electrical and Electronics Engineers (IEEE)
 - | US-based organization, located in New York City
 - | Formed in 1963
 - | Structured in “societies” (Communications Society and Computer Society are the most relevant for mobile networks) and working groups
 - | Previously standardized Ethernet and WiFi
 - | In charge of the WiMAX series of standards
 - | Convergence between the telecommunications and computer networks worlds

Standardization

- | Internet Engineering Task Force (IETF)
 - | Formed in 1986
 - | In charge of developing and promoting Internet standards
 - | Publishes “requests for comments”
 - | Increasing importance following the all-IP transition
 - | Major standards for mobile communications: Mobile IP and Network Mobility (NEMO)

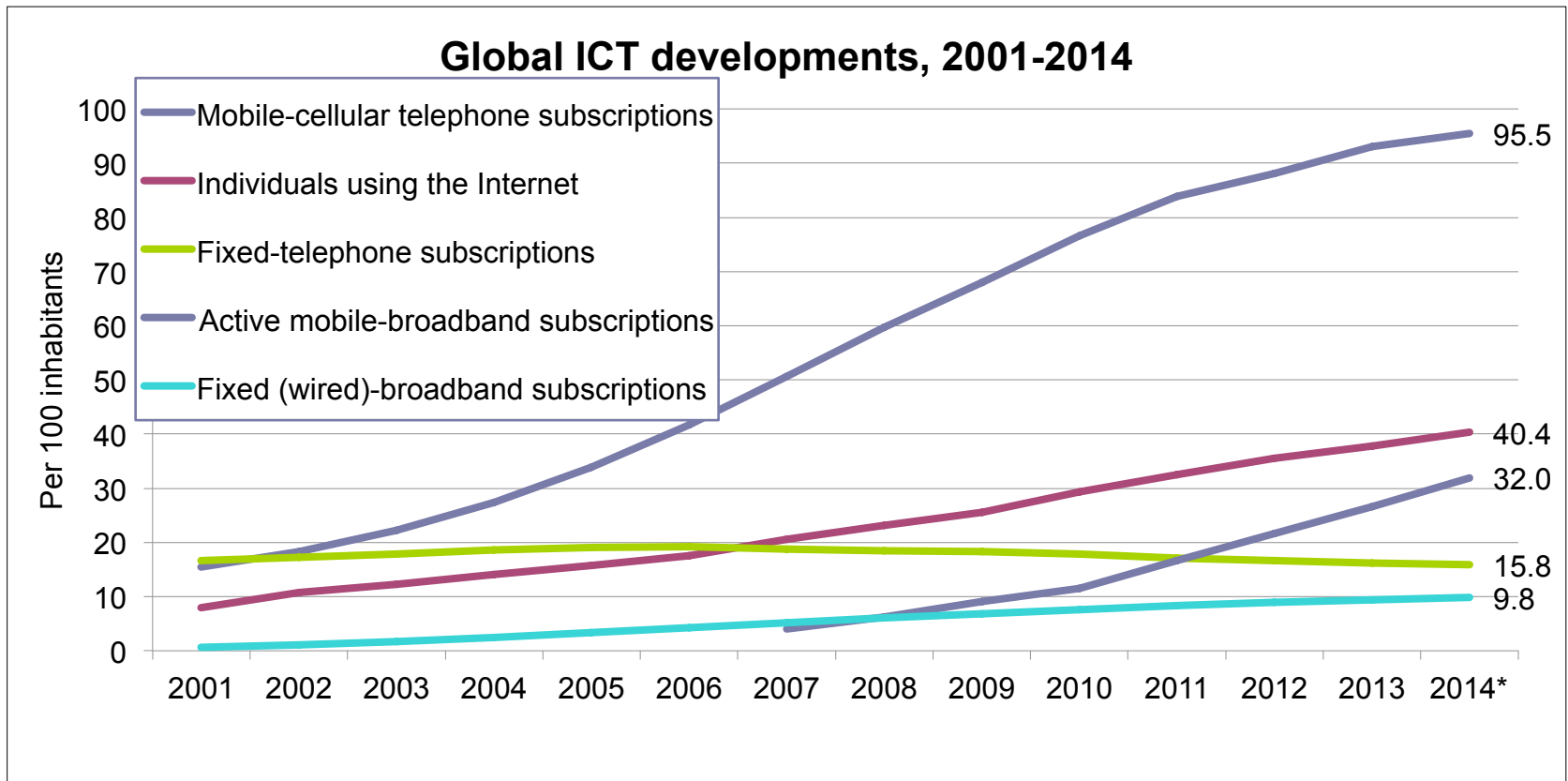
Standardization

| In France

- | Agence Nationale des Fréquences (ANFR), in charge of managing and controlling the use of electromagnetic frequencies.
- | Autorité de Régulation des Communications Electroniques et des Postes (ARCEP) in charge of deciding the obligations and controlling the activity of mobile operators

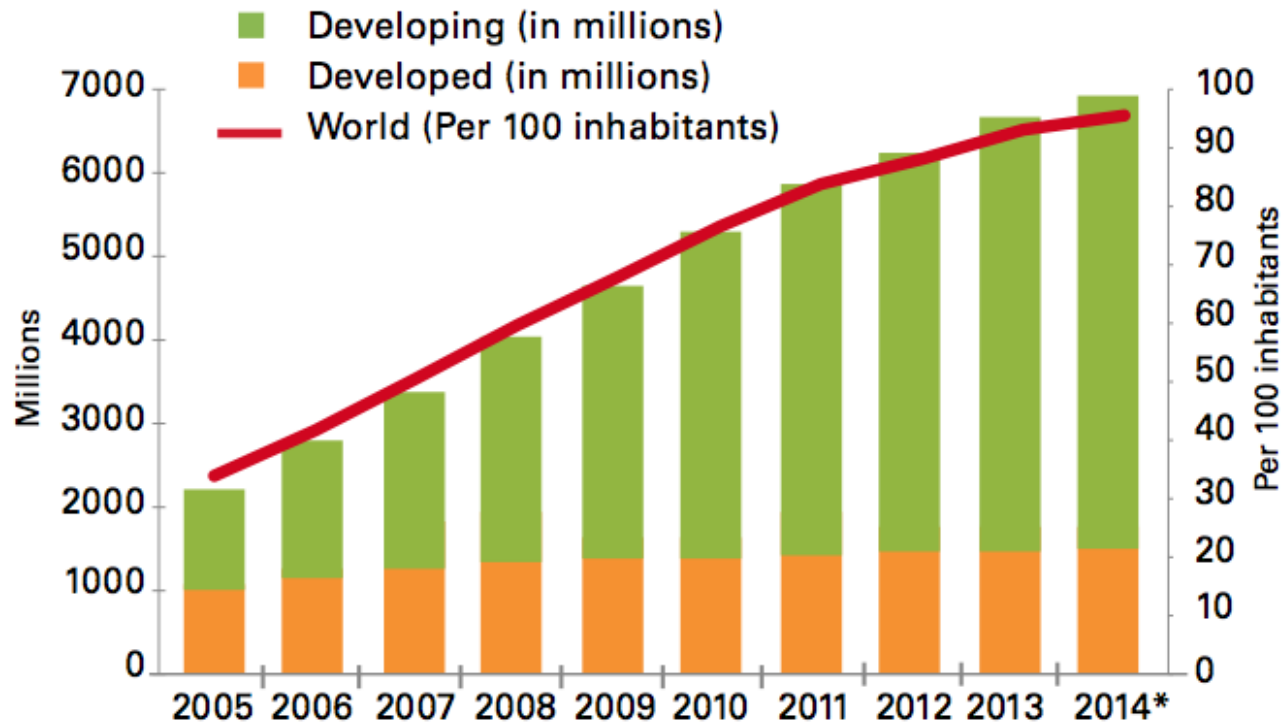
Some statistics

Mobile phone penetration rate



Some statistics

Mobile phone penetration rate

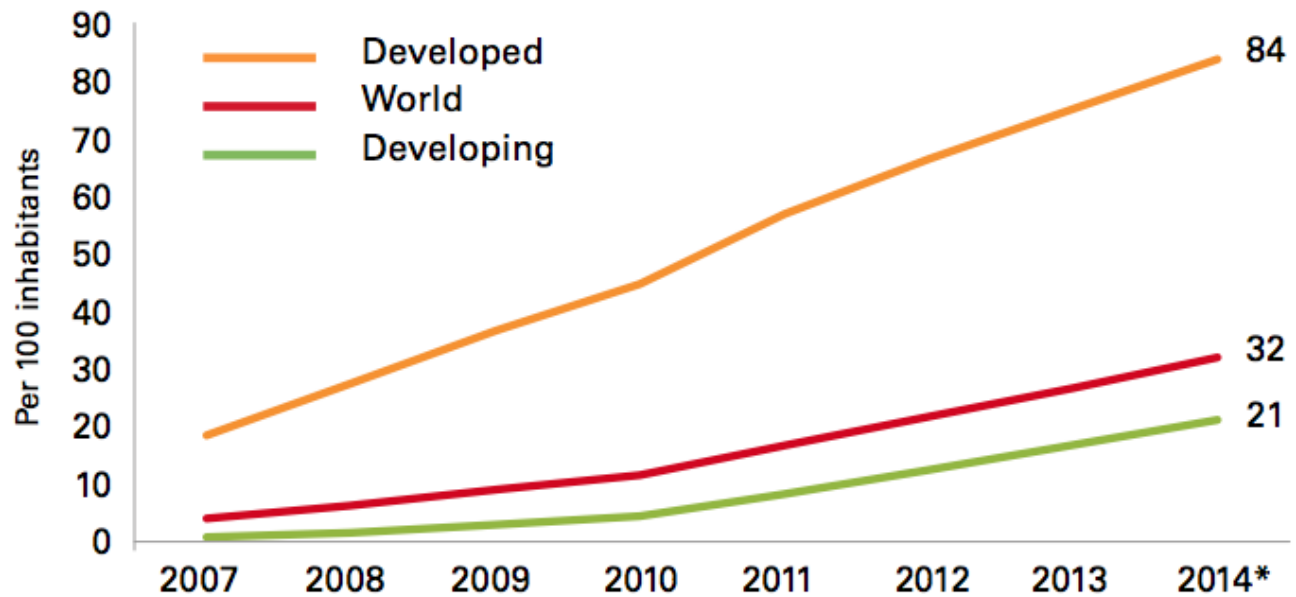


Note: * Estimate

Source: ITU World Telecommunication/ICT Indicators database

Some statistics

Mobile phone penetration rate

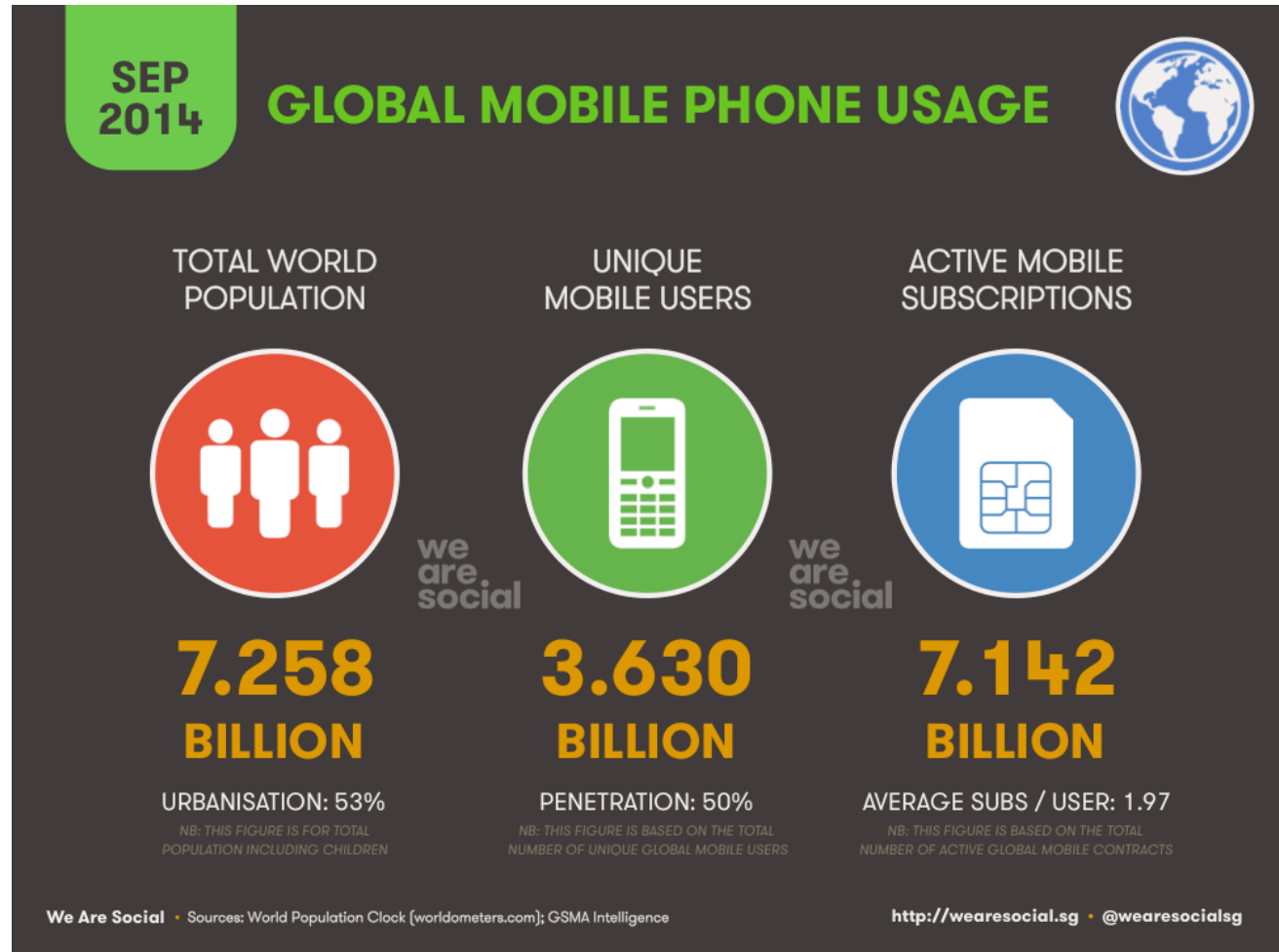


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Some statistics

Mobile phone penetration rate



Some statistics

Mobile phone usage

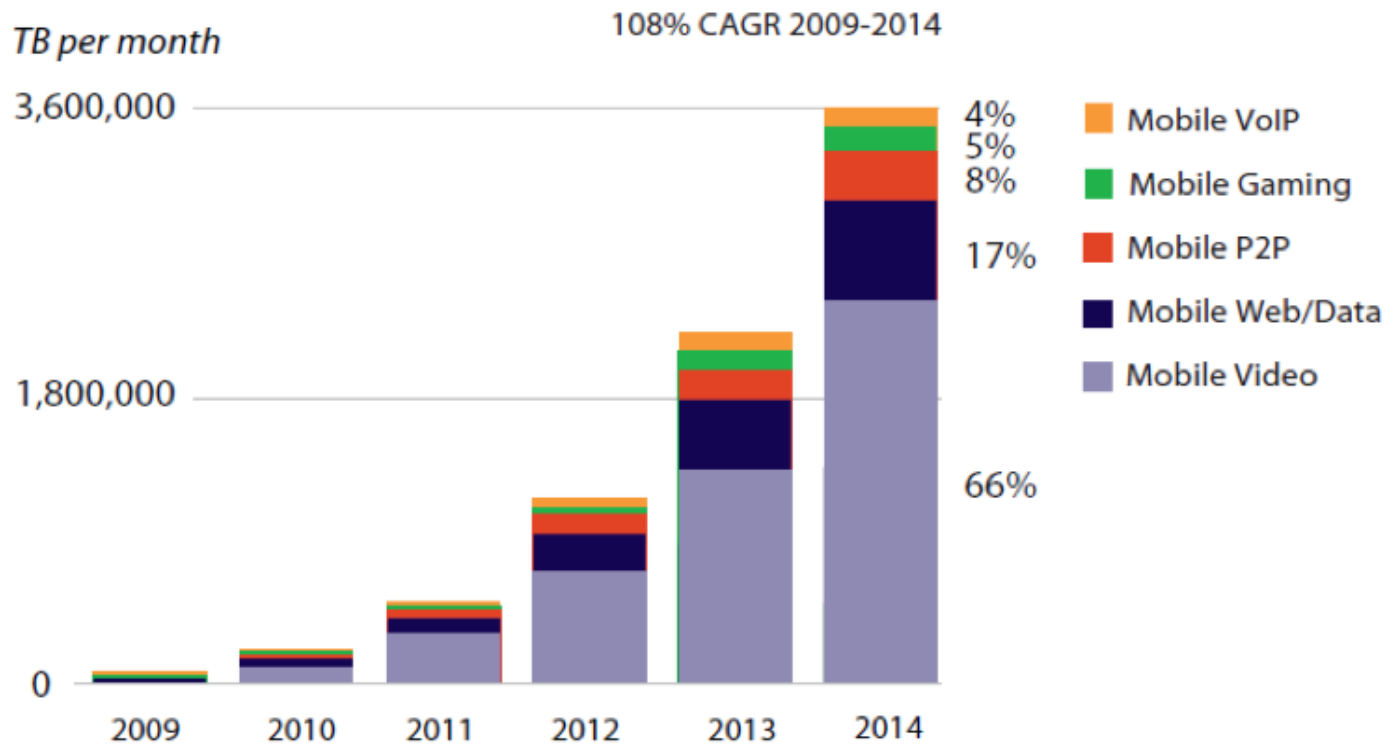
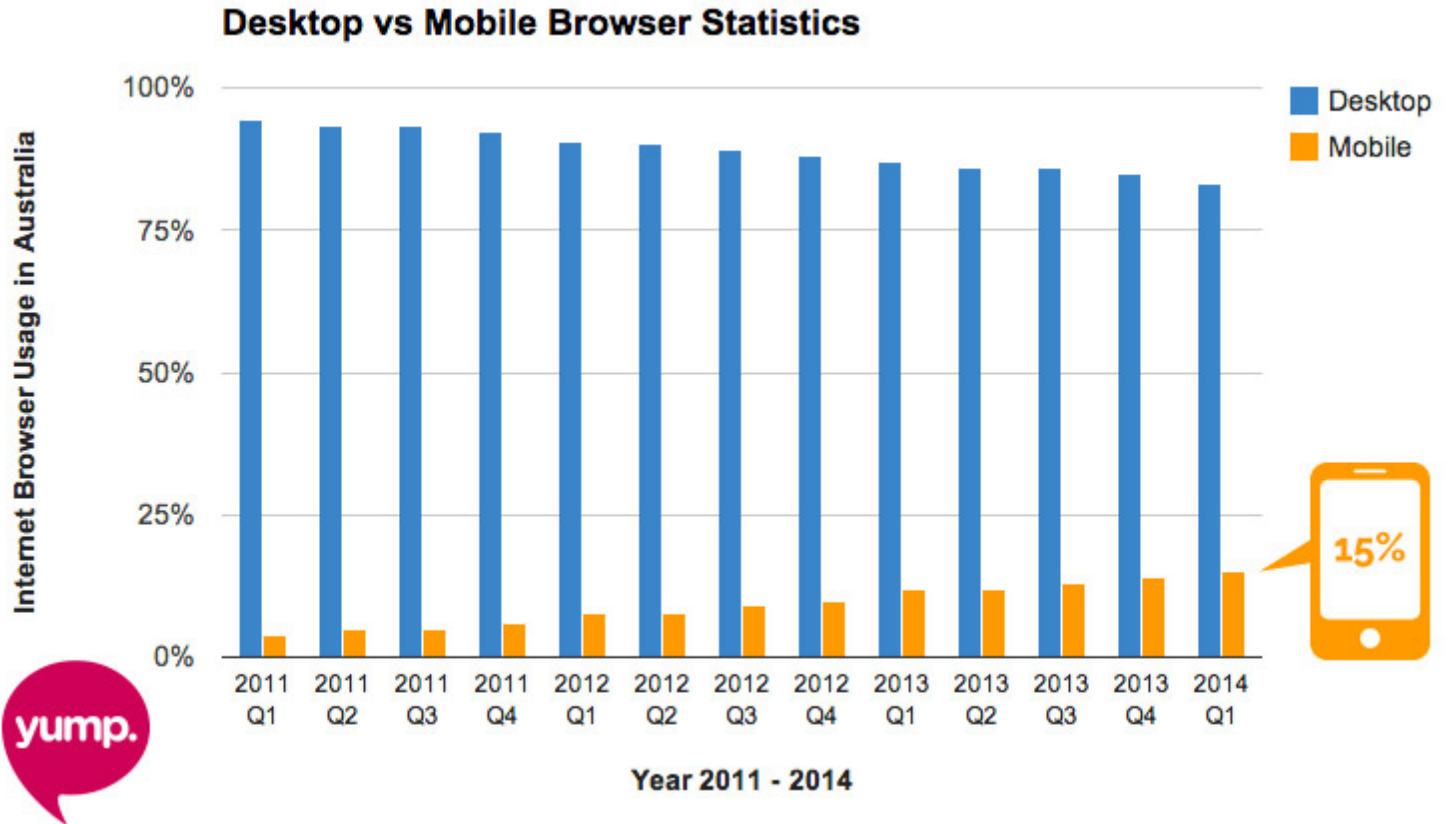


Figure 3: Mobile internet traffic growth
Source: Cisco VNI Mobile, 2010

Some statistics

Mobile phone usage

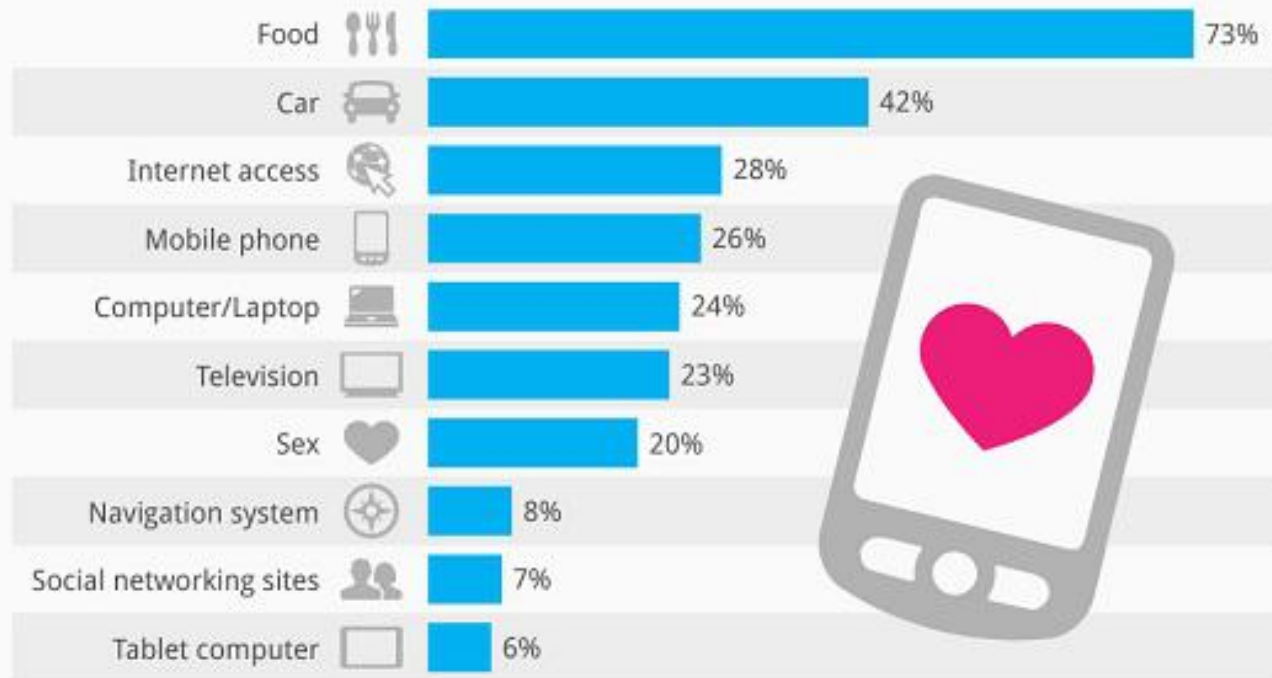


Some statistics

Mobile phone usage

Mobile Phones Are More Important Than Sex

% of U.S. adults who could not live without ...



Conducted online in June 2013 among 2,210 adults
Source: Harris Interactive

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