3.5 3G and 4G Mobile Radio Networks

The main reason for 3G systems application it is the tendency of worldwide standard, which can provide convergence of the wired and mobile networks. The idea lies in elimination of 2G systems incompatibility by using of existing wired and mobile networks infrastructure. We expect, that system should be global, which could be achieved by using enhanced cellular system. All types of networks (satellite – global coverage, terrestrial – macro-, micro- and picocell) will be covered by mentioned 3G system [27], [28].

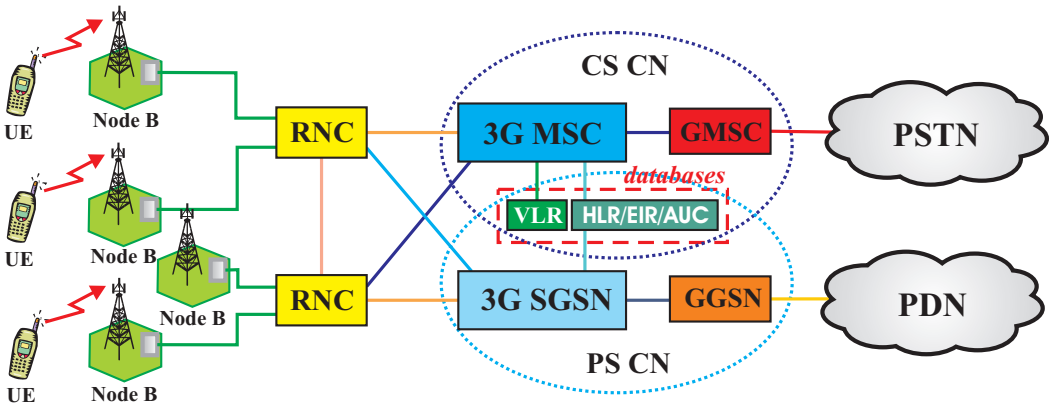
The development of UMTS standard tended to such a solution, that revolution tendency of UMTS network development was abandoned. Evolution steps from 2G to 3G systems were preferred, especially the use of a high developed GSM standard [30], [31], [27]. There were three crucial decision accepted with creation of infrastructure:

- To use the multiple accesses based on **CDMA** (*Code Division Multiple Access*) for radio interface.
- To create the UMTS terrestrial mobile access network by ATM transfer mode.
- To use the enhanced GSM 2+ network elements for UMTS core network.

Because the GSM standard is widespread global world standard of 2G networks, in the first step it is expected to use a connection of *UMTS Terrestrial Radio Access Network* (**UTRAN**) to existing but newly regenerated core GSM network. That means that GSM network will serve users of both technological standards in parallel. Radio subsystem of GSM network and UTRA network will work as two different, but cooperating and subsidiary access networks in generic network infrastructure, which can be regarded as GSM and also UMTS core network. The difference between them lies in the modernization of the some nodes of GSM network for UMTS network. In the second step the core network will be changed to IP network. 3G network architecture is on Figure below.

In different prognosis of 2G to 3G networks evolution, there exists standard, which is often marked as intermediate step between GSM and IMT-2000 networks – standard **EDGE** (*Enhanced Data Rates for GSM Evolution*). EDGE belongs to 3G standards, but on the contrary to UMTS standard, it needs essentially minor changes in radio access network and core network. For this reason, EDGE represents a simpler solution for operators of existing GSM networks. The EDGE actually represents 2nd generation of HSCSD and GPRS systems. This standard is not able to provide transfer rates up to 2 Mbps. The advantage of this standard lies in its simpler application without requirement to change the infrastructure. For this reason a lot of operators consider IMT-2000 like ideal standard for newly built 3G networks.

The 4th generation of mobile communication systems (4G) probably won't be based on the creation of a new standard, because it is clear, that neither 2G nor 3G networks were successful in enforcing the worldwide global standard. The main motive for building a 4G system, which is often called as system beyond 3G (B3G), will be probably tendency of economic success based on users' requirements for new and advanced services with high security and reliability. Also, there will be a tendency for budget-priced and easy terminals with long lifetime of batteries.

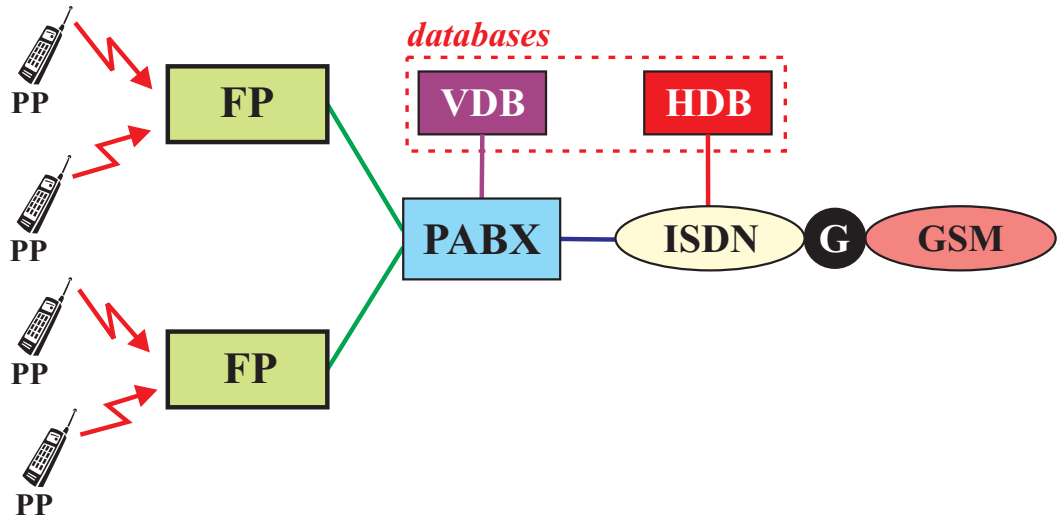


G3 network architecture

3.6 Cordless Telephone (DECT)

DECT (*Digital Enhanced Cordless Telephone*) standard is a boundary milestone of the long-term development. Since from beginning, this system was designed for wireless telephony in consideration of GSM standard and with connections to other networks. It is not proper to consider this system as a replacement of already existing networks, but as creation of a bridge between wireless and cellular technologies.

DECT is full digital system, transparent for PSTN services, providing mobility in user' premise (home, work). Coverage is realized by picocells with small cells (radius approximately 50 m), channel selection and channel allocation is dynamic (DCS/DCA), handover of calls is without interruption, provides roaming. Data transmission rate is 24 to 522 kbps (2 Mbps in the future). System has big capacity (10 000 Erl/km^2). This system is very flexible, because of predefined profiles, which enable cooperation with other networks. Primarily, DECT system was prepared for radio coverage of small areas and for cooperation with GSM network, which is not constructed for such small areas.



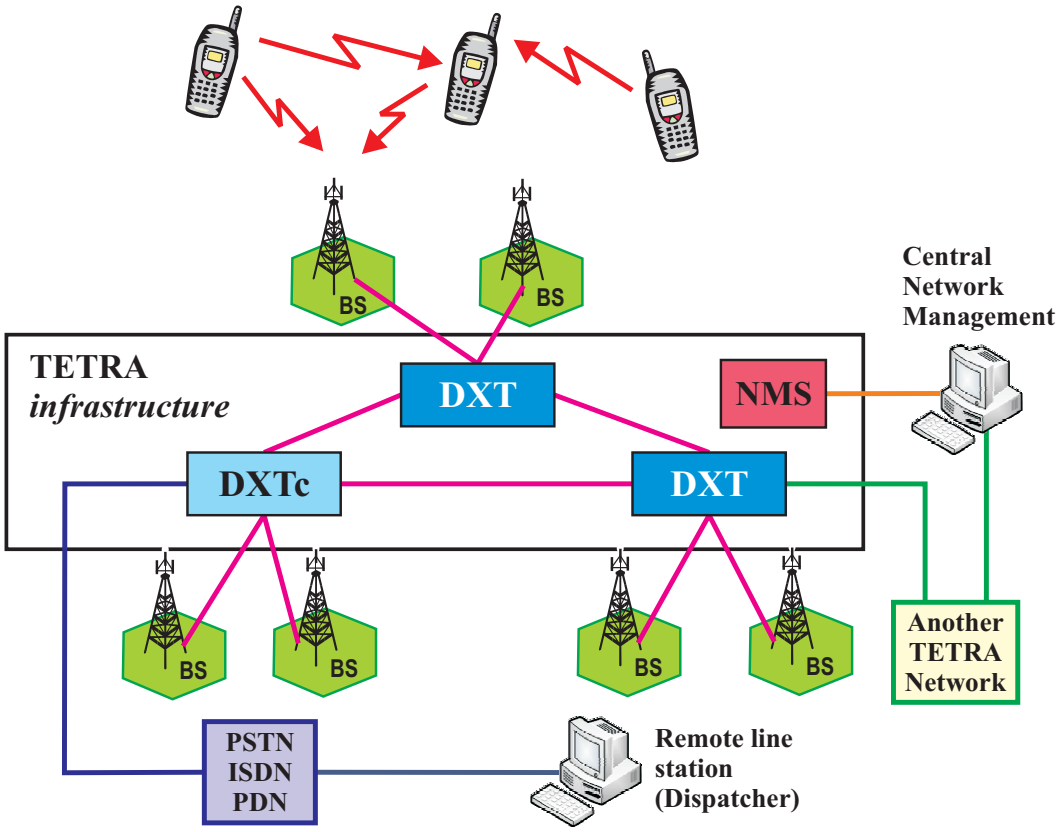
DECT network structure

3.7 Private Mobile Networks

A lot of financial resources for building of an infrastructure by means of base stations and antenna towers were often required to invest for necessity of radio communication coverage in the case of the classical radio networks by little and major users. Public cellular networks have a certain specifications, which support team works of subscribers, but with certain restrictions. This absence is mostly sensitive in work of some organizations like Police, Customs Service, emergency teams [27], [28].

\+ The solution of these problems lies in private radio trunking networks, which are able to use the same network for several organizations with preserving of secrecy and guarding of data and voice transfer. These networks provide an access to radio channel without great investment because they are able to join one or more systems and to invest to necessary mobile and portable terminals.

Standard for analog private radio networks in Europe represents the group of standards MPT 1317. This group consists of four standards, from which the best known is MPT 1327 one. **TETRA** (*Trans–European Trunked Radio*) is the first European opened digital radiotelephony standard defined by ETSI in 1995 [32]. The same way, as public mobile networks were progressively substituted by GSM network in a mobile radiotelephony, digital networks based on new standard will substitute today's analog terrestrial mobile private networks. TETRA network architecture is in following Figure.



TETRA network architecture

Among basic services of the network belongs the distribution of information for specific group or for each network user (analogy to paging networks). The other services include: e-mails, fax and SMS messages, transfer of data files, and safe access to databases or transport of information from GPS system.

From technological aspect, TETRA consists of two base standards:

- TETRA Voice + Data,
- TETRA Packet Data Optimized (TETRA PDO).

TETRA V + D is a radio trunking network standard for voice and data transfer. TETRA PDO is special version of packet transfer in radio channel, permitting of high effective using of limited radio spectrum. TETRA PDO can realize quite high transfer rates (36 kbps), and with superior methods of compression, system can transfer video sequences (for example: police can send signal of video record from the place of accident to police station, where it can be analyzed). System TETRAPOL, like TETRA is a digital private communication network, but it works on different multiple access method (TETRA – FDMA/TDMA, TETRAPOL – FDMA). Standards are not compatible.

3.8 Ad-hoc Networks

Ad-hoc network is a network created without any central control or management. This network is based of mobile nodes, which use wireless interface to transfer of data packets. Nodes in network are able to work as routers and they can route packets for other nodes. Ad-hoc connection is based on peer-to-peer type of communication. To provide a connection among mobile units it is not used any cable infrastructure and there is no central control to manage a creation of connections and to support the coordination and communication. Furthermore, there is no intervention from operators.

In general, in ad-hoc networks all devices, which share a common space, will also share common channel and they will be equivalent in this sharing each other.

These networks can be applied for network creation in such areas, where there is no infrastructure available, for example by emergency operations in far-away areas and for wireless public access in metropolitan areas – access nodes can serve as fixed relay stations for packet routing among each other [27]. On local level they are used for connection of notebooks, palmtops, e.g. at the conference, creation of home network, creation of personal networks and also for surroundings monitoring and realization of WLAN networks.

Wireless Local Area Network (**WLAN**) as a main representative of Ad-hoc networks can operate in two configurations, either as independent configuration (ad-hoc) – stations communicate directly and there is no necessity to install any supporting infrastructure, or as distributive system configuration – configuration expects existence of *access point* (**AP**), which at the same time works as a base radio station and as a data bridge. Wireless local networks can be divided into radio technology networks and *infrared* (**IR**) technology networks. IEEE 802.11 (WiFi), HIPERLAN and Home RF standards belong to radio technology networks [28].

Bluetooth

Bluetooth technology represents the next radio technology of a short range, it has to be able to work in ad-hoc networks, which can be either independent, or works like a part of IP networks in all over the world, eventually as combination of both possibilities. The goal of this technology is to replace the cable connection among electronic devices by radio channel by means of cheap radio chip. The key characteristics of this technology are robustness, small complexity, low power and small price. Bluetooth works in **ISM** (*Industrial-Scientific-Medical*) band of 2.4 GHz and uses frequency hopping to eliminate of interference and fading. Coverage is about 10 meters (possible connection through walls of building), transmission rate is 780 kbps (one-direction transmission is 721 + 57.6 kbps, symmetric transmission is 432.6 kbps).

The following table presents bit rates survey, which networks technologies of particular generations can ensure.

Mobile technologies and their bit rates

Distribution of technology		**Maximal bit rate downlink/uplink [Mbit/s]**
2G/2.5G/2.75G	GPRS	0.080/0.040
	EDGE	0.236/0.236
	EDGE Evolution	1.9/0.9
3G/3.5G/3.9G	UMTS	0.384/0.384
	HSPA	14.4/5.75
	HSPA+	56/22
	LTE	360/80
	Flash – OFDM	15.9/5.4
	WiMAX	144/35
4G	LTE Advanced	1 Gbit/s fixed connections and 100 Mbit/s mobile
	WiMAX IEEE 802.16m	
Others	WiFi 802.11b,g	54/54
	WiFi 802.11n	600/600