UMTS Standardization

UMTS Release 99 (2000)

- Based on GSM,
  - Backward compatible with GSM,
  - Interoperation between UMTS and GSM,
- Definition of the UTRAN
- UTRA
  - UMTS FDD (W-CDMA)

UMTS Release 4 (2001)

- Separation of user data flows and control mechanisms,
- UMTS TDD Time Division CDMA (TD-CDMA),
  - High data rate with UMTS TDD 3.84 Mchips/s,
  - Narrowband TDD with 1.28 Mchips/s,
- Position location functionality.

UMTS Standardization

UMTS Release 5 (2002)

- End-to-end packet switching based on IP (IMS)
- Downlink data rate of over 10 Mbps (HSDPA),
- GSM EDGE Radio Access Network (GERAN).

UMTS Release 6 (2004)

- IMS "Phase 2" (IMS messaging, conferencing and Group Management),
- High Speed Uplink (HSUPA) ,
- Multimedia Broadcast / Multicast Service (MBMS) ,
- WLAN interworking .

UMTS Standardization

UMTS Release 7 (2007)

- Enhanced Uplink, other spectrum,
- Multiple Input Multiple Output antennas (MIMO),
- IMS Emergency Call handling.

3GPP Release 8 (2009)

- 3GPP Long Term Evolution (LTE) ,
- Successor to UMTS,
- Sometimes called 3.9G.

3GPP Release 10 (expected in 2011)

- Long Term Evolution Advanced 4G,
- Full ITU-R 4G requirement compliant (peak download rate 1Gbit/s)
- Possible technologies: Scalable spectrum 20-100Mhz, Cognitive Radio …

HSPA

High Speed Packet Access

- An extension with increased data rates for UMTS consisting of HSDPA and HSUPA
- Optimization is achieved by:
  - Up to 14 Mbps downlink and 5.8 Mbps uplink
  - Lower delay (latency)
- HSPA can usually be achieved through a software upgrade to existing UMTS networks
- Most GSM/UMTS network operators have already introduced HSPA.

HSDPA

High Speed Downlink Packet Access

- Enables in current specification of UTRAN up to 14 Mbit/s downlink data rates
- First, network operators offered a 3.6 Mbit / s version
- Since 2008, network operators also offer 7.2 Mbit / s
- Part of Release 5 of 3GPP
- Can be used for UTRAN FDD and TDD
- Uses the 16QAM modulation scheme
- HSDPA requires a 5 MHz band (already used in Germany for UMTS)
- Transmission power in a whole cell is optimized and the data rate adjusted accordingly, rather than just for one channel, all possible channels are used for data transmission
- Voice traffic has always higher priority

HSDPA

Modulation	FEC coding	5 channels	10 channels	15 channels
QSPK	1/4	0,6 Mbit/s	1,2 Mbit/s	1,8 Mbit/s
	2/4	1,2 Mbit/s	2,4 Mbit/s	3,6 Mbit/s
	3/4	1,8 Mbit/s	3,6 Mbit/s	5,4 Mbit/s
16QAM	2/4	2,4 Mbit/s	4,8 Mbit/s	7,2 Mbit/s
	3/4	3,6 Mbit/s	7,2 Mbit/s	10,7 Mbit/s
	4/4	4,8 Mbit/s	9,6 Mbit/s	14,4 Mbit/s

HSUPA

High Speed Uplink Packet Access

- Part of 3GPP Release 6
- Increases the maximum uplink rate of UMTS up to 5.8 Mbps
- Employs up to 6 codes simultaneously
- Less error-prone BSPK is used

HSPA

UMTS	2004	Downlink	0,384 Mbit/s	
		Uplink	0,064 Mbit/s	
HSPA	2006	Downlink	1,8 Mbit/s	
		Uplink	0,384 Mbit/s	
HSPA	2007	Downlink	3,6 Mbit/s	
		Uplink	1,8 Mbit/s	
HSPA	2008	Downlink	7,2 Mbit/s	
		Uplink	3,6 Mbit/s	

Latency (ping) comparison

GPRS	600 ms and more	
EDGE (EGPRS)	400 to 500 ms	
UMTS	200 to 300 ms	
UMTS with HSPA	100 to 200 ms	

HSPA + / HSPA Evolution

Transmission technologies for more effizient spectrum utilization

- 64QAM in downlink
- 16QAM in uplink
- MIMO (Multiple Input Multiple Output)
- Introduction by T-Mobile, Vodafone and O2 in 2009 in Germany and Spain

Spezifikation	HSDPA (Downstream)	HSUPA (Upstream)
HSPA+ Release 7	28,0 MBit/s	11,5 MBit/s
HSPA+ Release 8	42,2 MBit/s	11,5 MBit/s
HSPA+ Release 9	84 MBit/s	11,5 MBit/s

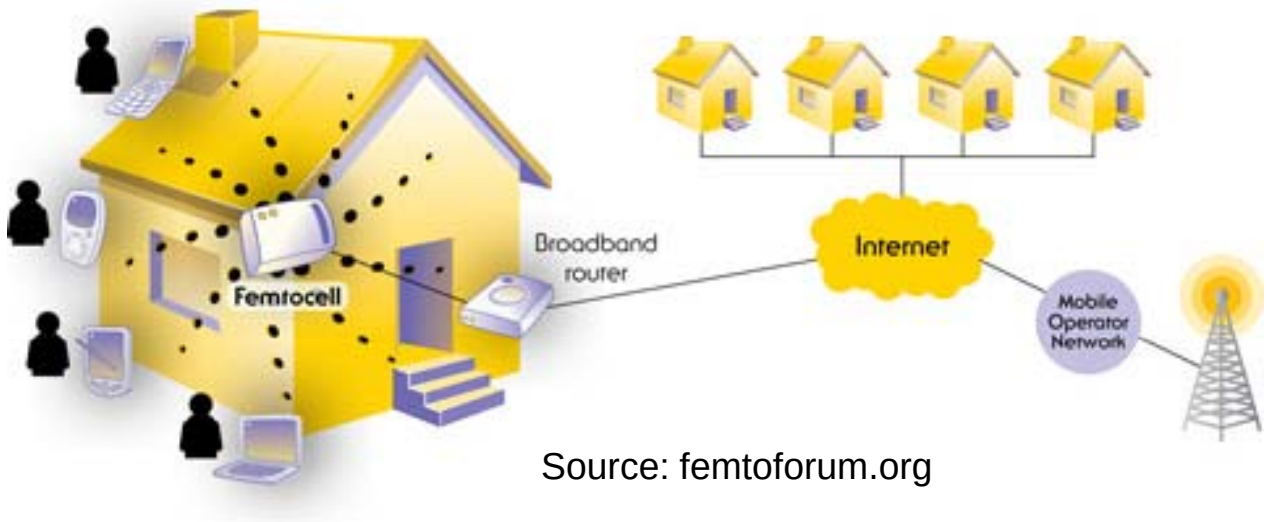
LTE - Long Term Evolution

Innovations

- 20MHz-wide channels (UMTS only 5 MHz) in 2.6 GHz band
- Frequency allocation in 2010
- OFDMA with 64QAM
- MIMO (such as HSPA + and 802.11n)
- Target real-world data rates of 100 Mbps downlink and 50 Mbps .
- Theoretically 326.4 Mb/s for 4x4 antennas and 172.8 Mbit/s for 2x2 antennas are possible on a 20 Mhz band.
- easy integration into existing UMTS / GSM networks and simple architecture with self-configuring base stations

Femtocells: Small UMTS „customer premesis„ BTS

- short-range, for example 10-20 m
- Increased service provision in buildings,
- Decreased spectrum pollution of regular (macro) cells by indoor users.
- although operated by the mobile network operator (MNO), the femto cell conects through the user‘s private DSL/Cable as backhaul to the MNOs core network.



Source: femtoforum.org

Femtocells: Small UMTS „customer premesis„ BTS

- Alternative to WiFi at homes of private customers, but due to usage of licensed spectrum, only available as a MNO service.
- Advantages:
  - homogeneous network infrastructure facilitates uninterrupted handover
  - no dual-mode (WLAN / UMTS) terminals required
- Challenges:
  - femto-femto interference an femto-macro interference
  - Dual-mode handsets (smartphones) are highly prevalent as of 2010
- Recent discussion:
  - Instead of femto cells, available 802.11 networks can be used with dual mode handsets to carry encapsulated UMTS packets via IP tunnel to MNOs core network.
  - Similar (macro) cell offloading effect

Fourth-generation cellular networks (4G)

The term 4G is associated with the integration of WLAN, WiMAX and LTE in cellular networks and the availability of much higher bandwidth (100-1000 Mb/s in real terms)

ITU (International Telecommunication Union) defines 4G as follows:

- 100 Mb / s, fully mobile use
- 1 Gbit / s in nomadic use

The spectrum for 4G was set by WRC (World Radiocommunication Conference) in October 2007
http://www.itu.int/newsroom/press_releases/2007/36.html

Samsung demonstrated in 2006 at a 4G Forum in Jeju Island, Korea a 4G bus with 100 Mbit/s at 60 km/h and 1 Gbit/s nomadic throughput.

Competing technologies: WiMAX and 3GPP LTE

Comparison of 3G and 4G

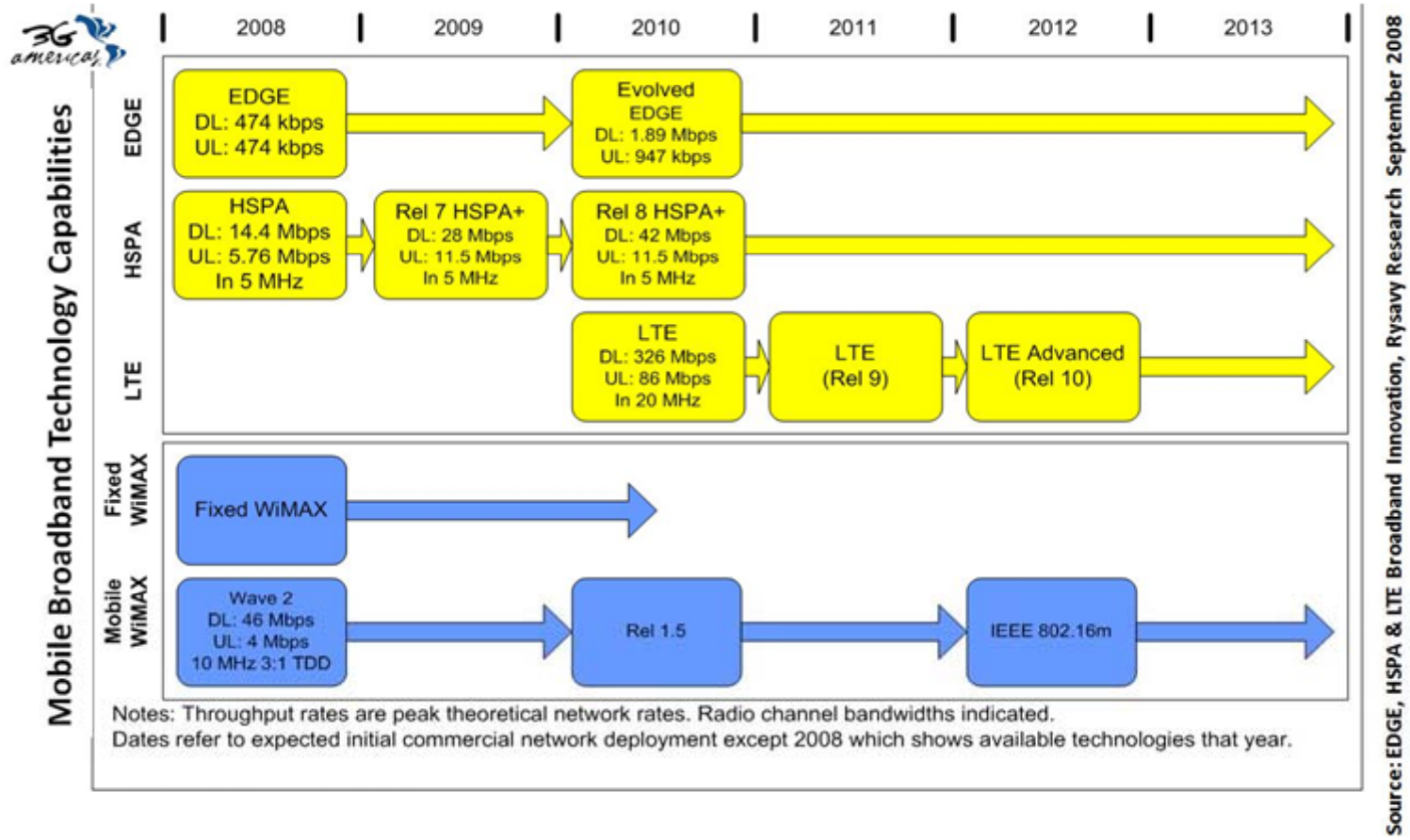
3G

- Backward compatible to 2G
- Circuit and Packet Switched Network
- Combination of existing & evolved equipment
- Data rate up to 2Mbps

4G

- Convergence of WLAN with cellular networks
- completely Packet Switched Network (All-IP)
- All network elements are digital
- Higher bandwidth, for example 100-1000Mbps
- Expansion of 3G capacity
- With LTE possibly backwards compatible elements of 3G networks

Generation 4 (4G) evolution paths to 4G



Innovations for 4G

- Modulation and multiple access techniques
  - Particular combination of OFDM with CDMA and TDMA
- Multiple antenna techniques
  - Minimization of multipath and similar problems by using multiple antennas at base stations and mobile stations
- All IP networks
  - Starting point: many private wireless access networks, usually based on 802.11, etc.
  - IP as a common platform
  - Commercial use based on AAA protocols (Authentication, Authorization and Accounting)
- News on 4G e.g. http://www.4g.co.uk/

Innovations for 4G

- Components of 4G Standardization:
  - UWB
  - 802.11n
  - SDR
  - 802.16-2005 (formerly 802.16e)
  - 802.16m
  - 3GPP LTE (evolution of UMTS)

5th Generation

- 5G is a research term, not currently used for a certain specification,
- It is expected in year 2020 with following possible properties

  - All IPv6
  - One unified global standard
  - Seamless Vertical handover (5G – WLAN/WPAN)
  - Multiple concurrent data transfer paths
  - High Altitude stratospheric Platform Stations (HAPS)
    - Quasi stationary aircrafts at ~ 20 km altitude
    - High throughput mobile data services.
    - Mesh like interconnection of HAPS
    - Lower cost than satellites and shorter round trip time.

5th Generation – Examples of HAPS

source: NASA , Lockheed Martin 's Flickr Page

TETRA - Terrestrial Trunked Radio

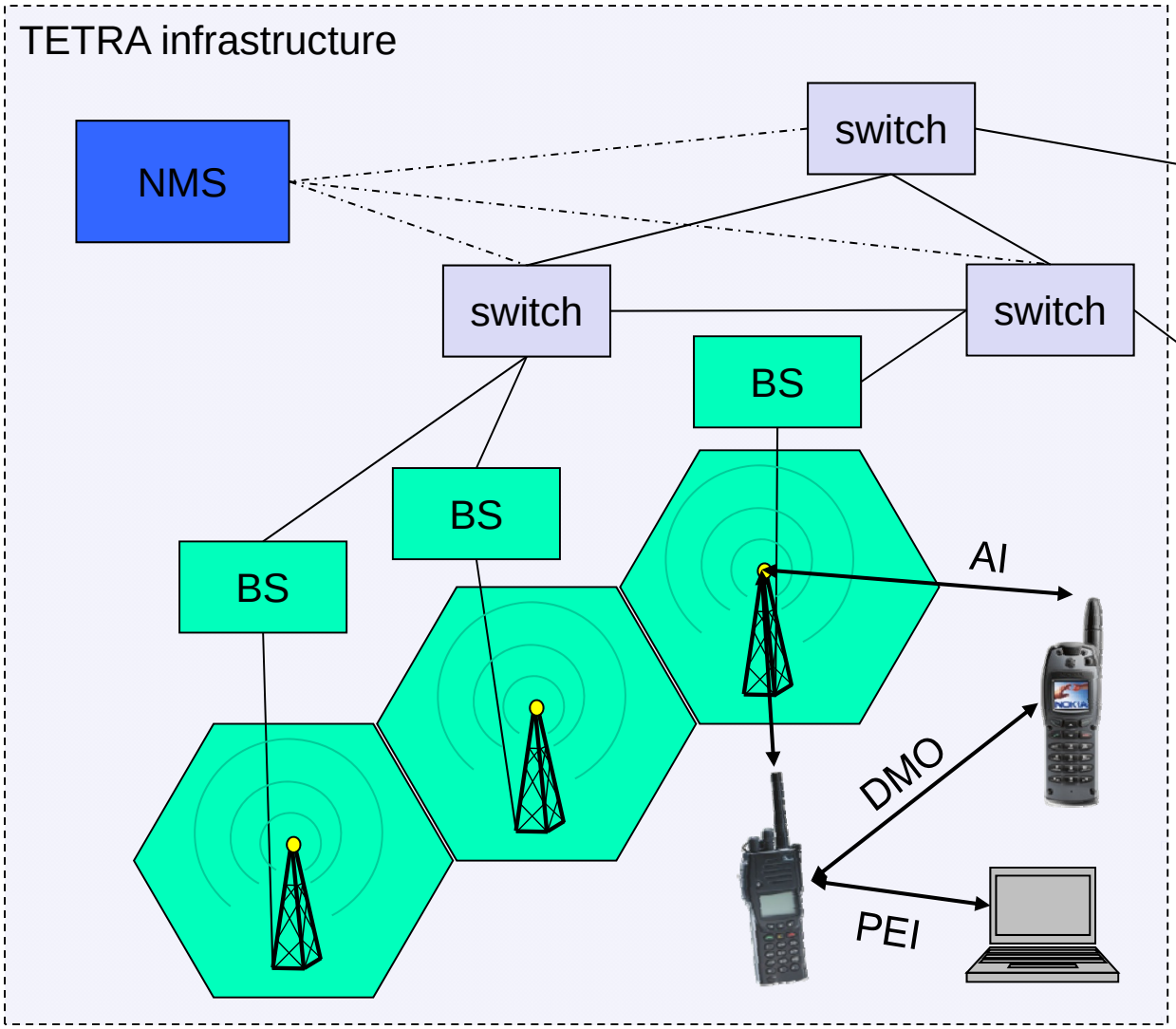
Trunked radio systems

- many different radio carriers
- assign single carrier for a short period to one user/group of users
- taxi service, fleet management, rescue teams
- interfaces to public networks, voice and data services
- very reliable, fast call setup, local operation

TETRA - ETSI standard

- formerly: Trans European Trunked Radio
- point-to-point and point-to-multipoint
- encryption (end-to-end, air interface), authentication of devices, users and networks
- group call, broadcast, sub-second group-call setup
- ad-hoc (“direct mode”), relay and infrastructure networks
- call queuing with pre-emptive priorities

TETRA – Network Architecture

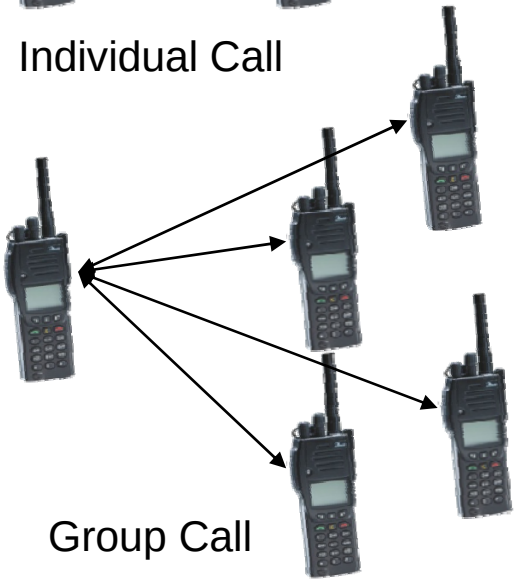


AI: Air Interface
BS: Base Station
DMO: Direct Mode Operation
ISI: Inter-System Interface
NMS: Network Management System
PEI: Peripheral Equipment Interface

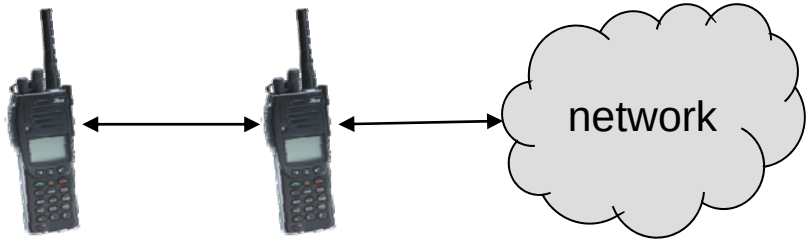
TETRA – Direct Mode I

Direct Mode enables ad-hoc operation and is one of the most important differences to pure infrastructure-based networks such as GSM, cdma2000 or UMTS.

Individual Call



Group Call



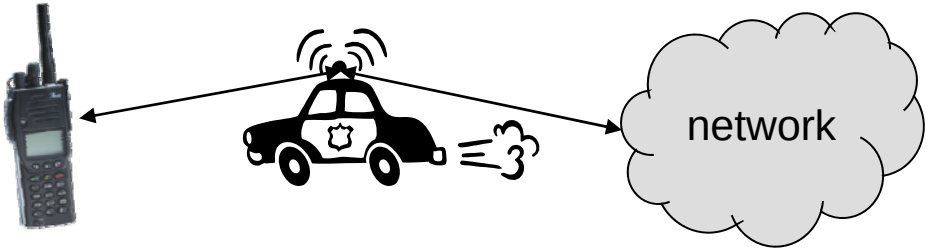
“Dual Watch” – alternating participation in Infrastructure and ad-hoc

Managed Direct Mode

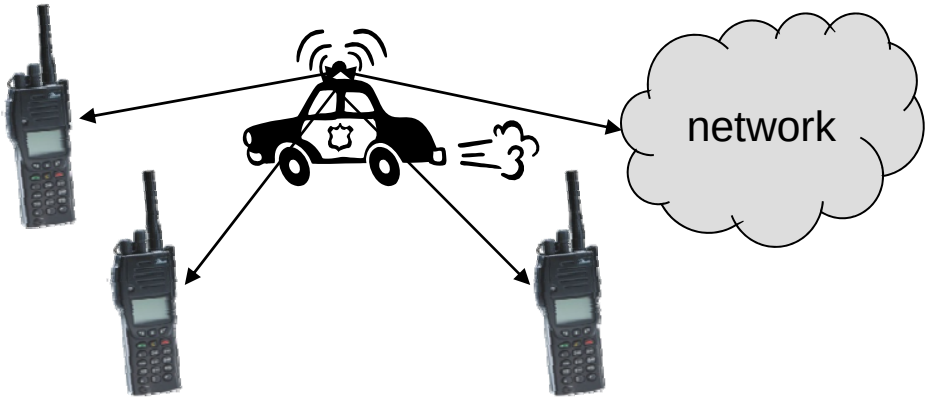
TETRA – Direct Mode II

An additional repeater may increase the transmission range (e.g. police car)

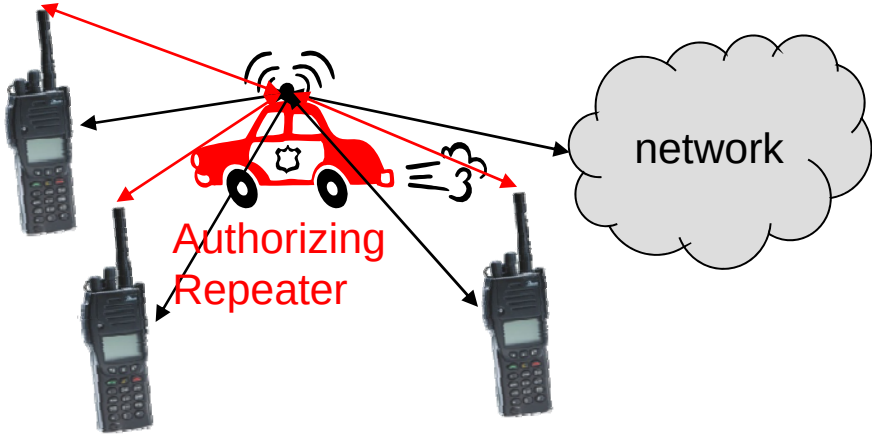
Direct Mode with Repeater



Direct Mode with Gateway



Direct Mode with Repeater/Gateway



Managed Repeater/Gateway

TETRA – Technology

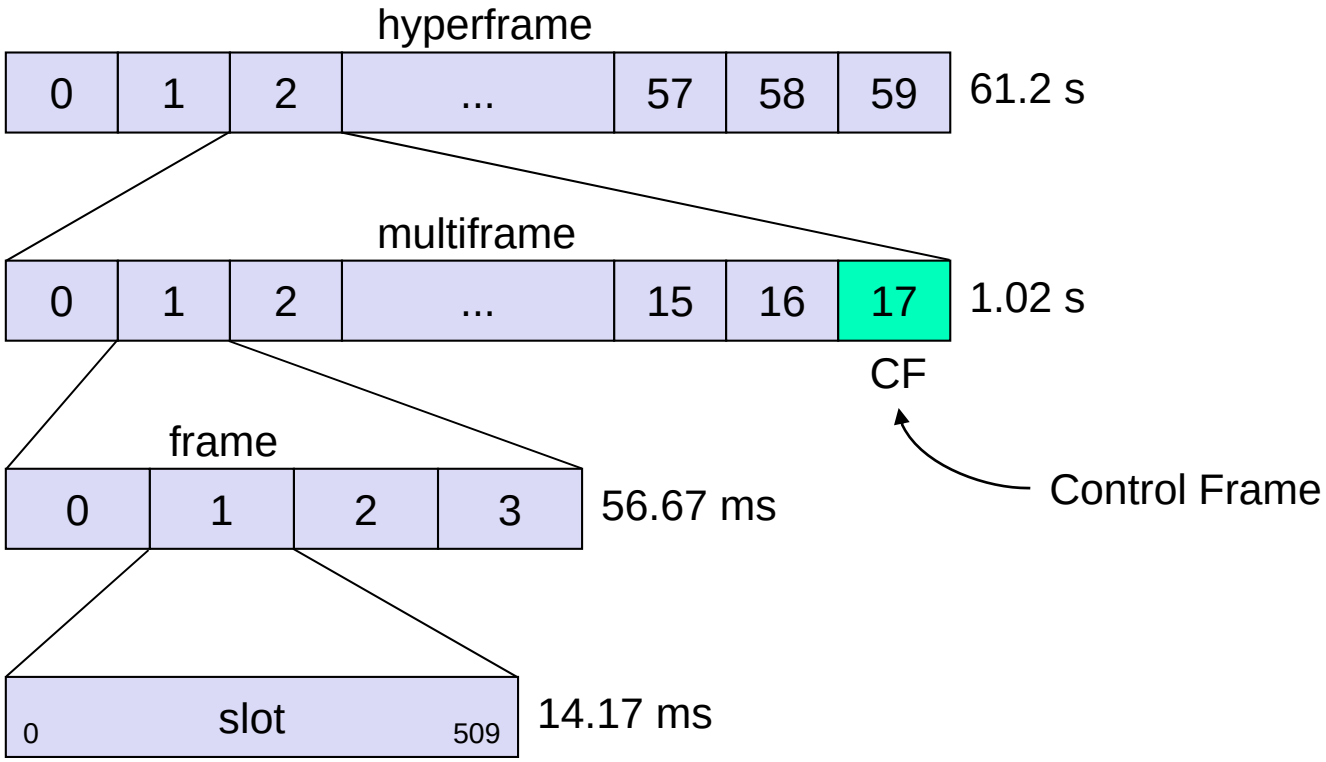
Services

- Voice+Data (V+D) and Packet Data Optimized (PDO)
- Short data service (SDS)

Frequencies

- Duplex: FDD, Modulation: DQPSK
- Europe (in MHz, not all available yet)
  - 380-390 UL / 390-400 DL; 410-420 UL / 420-430 DL, 450-460 UL / 460-470 DL; 870-876 UL / 915-921 DL
- Other countries
  - 380-390 UL / 390-400 DL; 410-420 UL / 420-430 DL, 806-821 UL / 851-866 DL

TDMA structure of the voice+data system



TETRA – Data Rates

Infrastructure mode, V+D in kbit/s

No. of time slots	1	2	3	4
No protection	7.2	14.4	21.6	28.8
Low protection	4.8	9.6	14.4	19.2
High protection	2.4	4.8	7.2	9.6

TETRA Release 2 – Supporting higher data rates

- TEDS (TETRA Enhanced Data Service)
- up to 100 kbit/s
- backward compatibility

TETRA – Contracts by Sector (percentage)

Used in over 70 countries, more than 20 device manufacturers