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Energy Efficiency Perspectives of PMR Cellular Systems

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Outline

- TeTRA system and architecture
- TeTRA power consumption model
- Energy efficient solutions for TeTRA/TEDS systems
- Energy saving gain of TeTRA over LTE

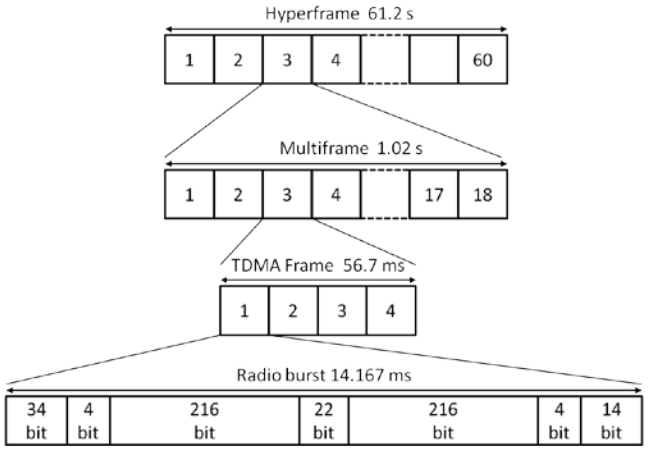
TeTRA system

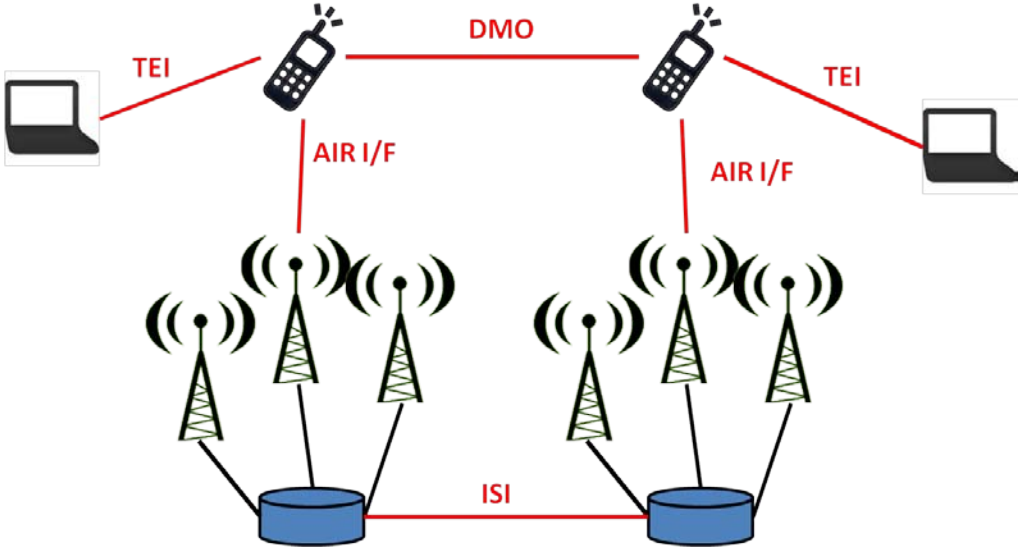
- Terrestrial Trunked Radio system

- Professional mobile radio (PMR)
  - Common system to provide mobile radio access to:
    - Military and public safety forces
    - Private companies

**Even if it is not the main priority,
the importance of the reduction of the energy costs in PMR systems has to be effectively dealt with.**

TeTRA architecture

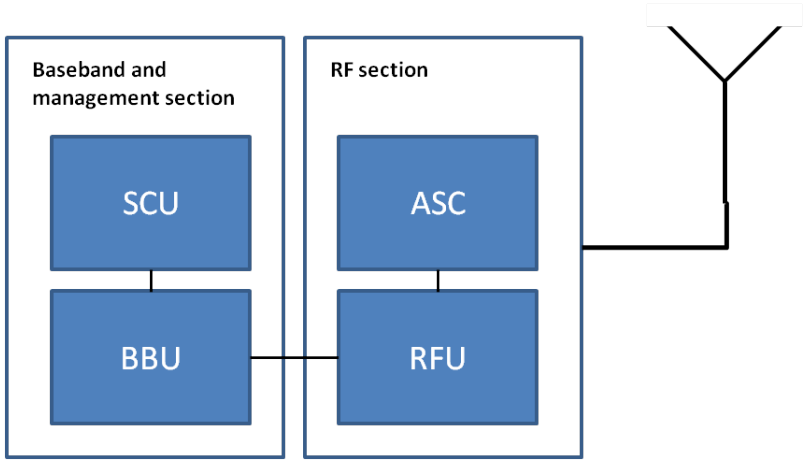




TeTRA architecture is similar to GSM

TeTRA Base Station

- BB and management
  - Site control Unit (SCU)
  - Base Band Unit (BBU)
- RF section
  - Antenna Switching Circuit (ASC)
  - Radio Frequency Unit (RFU)



SCU: management operations of the considered site
BBU: baseband signal processing operations
ASC encompasses the circuits which connect the RFU modules to the antenna system
RFU: RF operations on the transmitted and received signal

The number of SCU and BBU is variable and depends on the desired redundancy level.
The number of RFU depends on the number of carriers that are available in the site.

TeTRA power consumption model

Linear model

$$Pc = n_{RFU} \cdot P_{RFU} + P_{BBU} + P_{SCU} + P_{ASC}$$

RFU power consumption is the most important part

$$P_{RFU} = \alpha P_{TX} + P_{0,RFU}$$

RFU power consumption is composed by a fixed part and a variable part that depends on input power at antenna port.

Since the other components can be considered constant, the total power consumption is

$$P_c = n_{RFU} \cdot \alpha P_{TX} + P_0$$

$$P_0 = 274\ W \quad \alpha = 12$$

TeTRA energy efficient RRM

- Non-BCCH carrier sleep mode

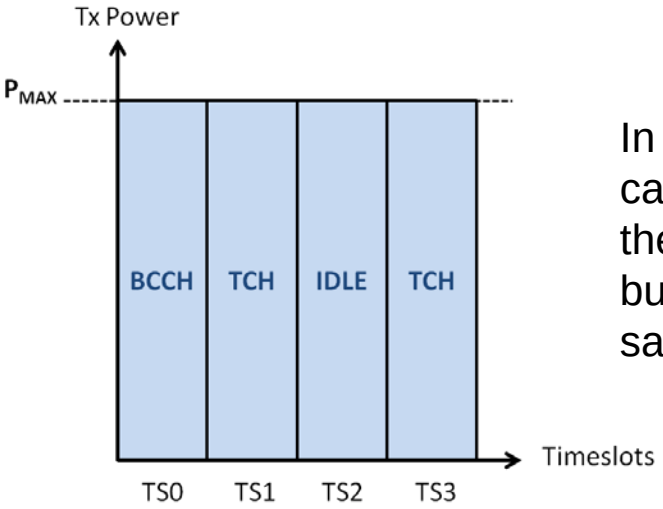
  RFUs that are not transmitting the BCCH could be put on a energy saving state when no TCHs are allocated.

  Already implemented in most TeTRA BS systems.

- BCCH power control

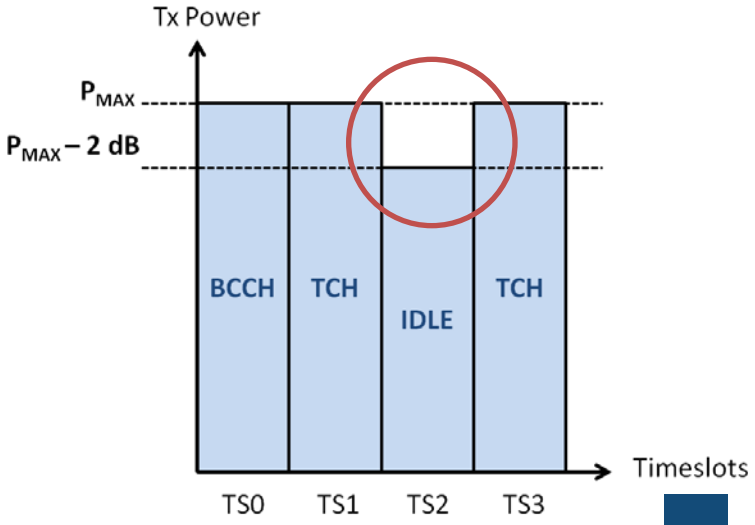
  Software based solution that allows to transmit dummy bursts on idle channels of the BCCH carrier at lower power than the maximum transmitted on BCCH.

BCCH power control

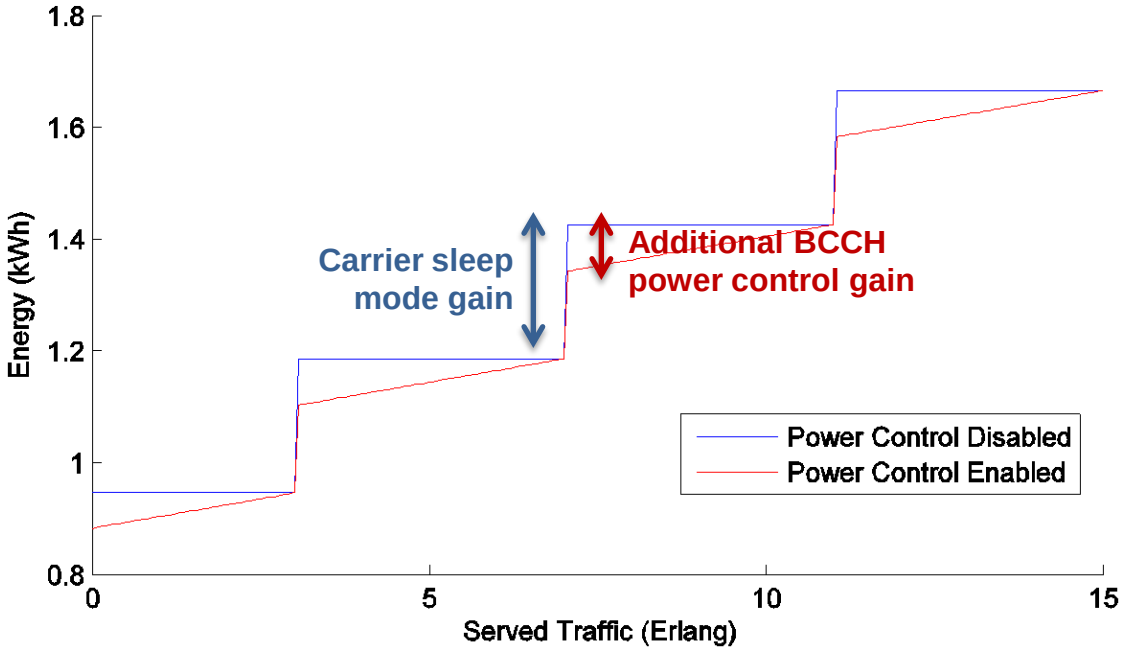


In normal conditions on IDLE channels on BCCH carriers are transmitted dummy bursts to maintain the synchronization of the TDM system. Dummy bursts on IDLE channel are transmitted at the same power of the BCCH.

An energy saving gain can be introduced by reducing power of IDLE channels since they do not carry any information useful for covered users.



BCCH power control



BS power consumption versus served traffic for the power control and no power control cases.

BCCH power Control allows to make the power consumtpion variable according to the served traffic.

Also carrier sleep mode is considered in the plot.

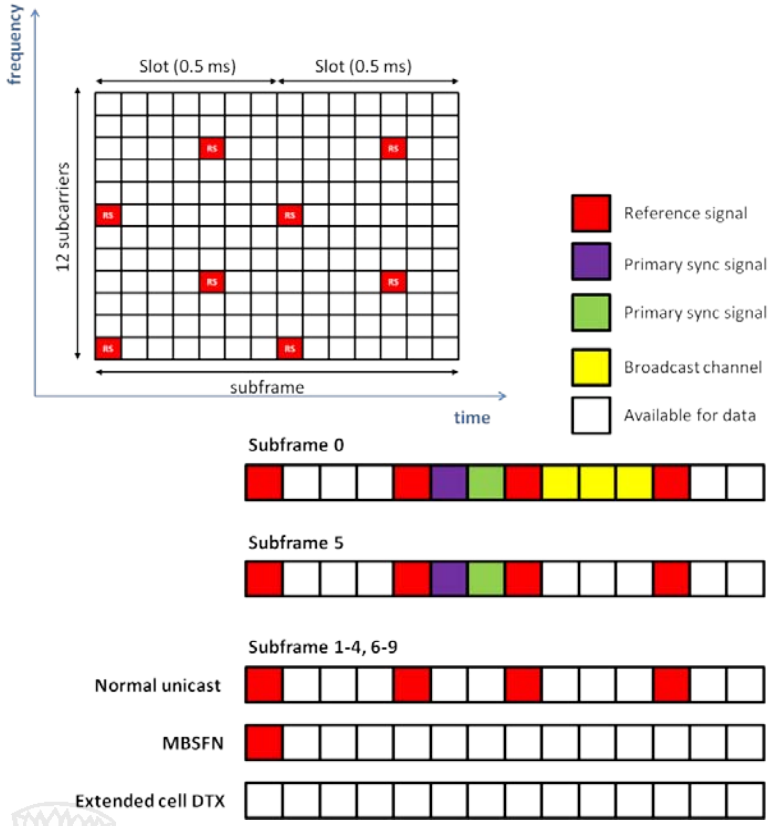
TeTRA over LTE

- LTE will be the widely deployed mobile broadband standard
  - all-IP system architecture
  - flexible radio interface
  - high data rates
  - low latency.

- LTE system provides some features that meet the PMR requirements
  - heterogeneous networks
  - intercell coordination
  - interworking with other radio access technology
  - unicast and broadcast service support.

- Some challenges are still to be solved before the implementation of a complete TeTRAoLTE system:
  - resilient and highly available infrastructure,
  - reliable and secure communications,
  - direct communications
  - group communications

LTE cell DTX



1 subframe = 2 time slots

No time domain sleep mode is possible because control signals are transmitted

MBSFN allows to switch off ½ time slots. If no traffic has to be transmitted, extended cell DTX allows 100% saving.

TeTRA over LTE energy consumption model

By resorting to cell DTX, LTE hourly energy consumption can be evaluated as

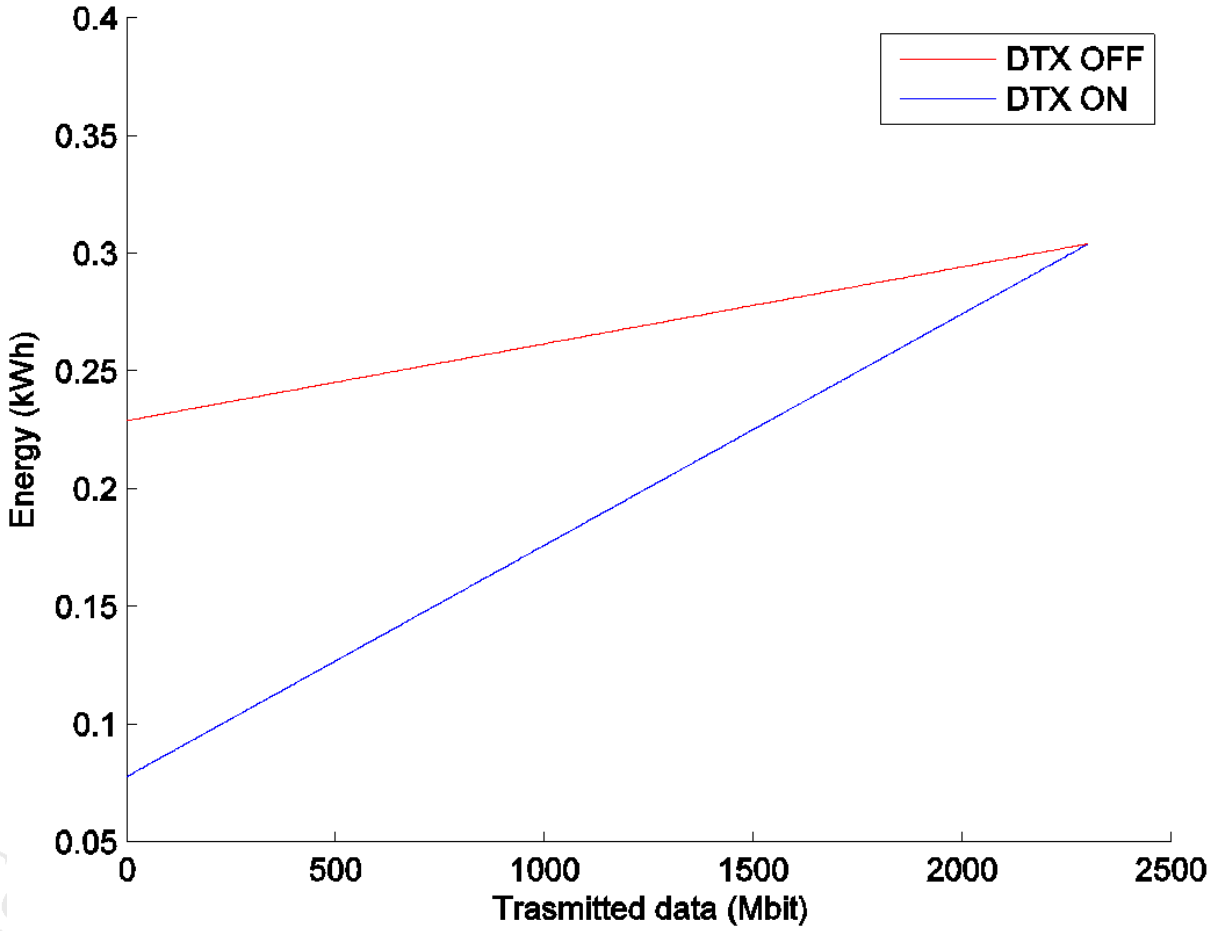
$$E_h = (\alpha P_{TX} + P_0)\mu_h + \epsilon P_{sleep}(1 - \mu_h) + (1 - \epsilon)P_0(1 - \mu_h)$$

The hourly load is the fraction of time the system is transmitting (traffic + signaling)

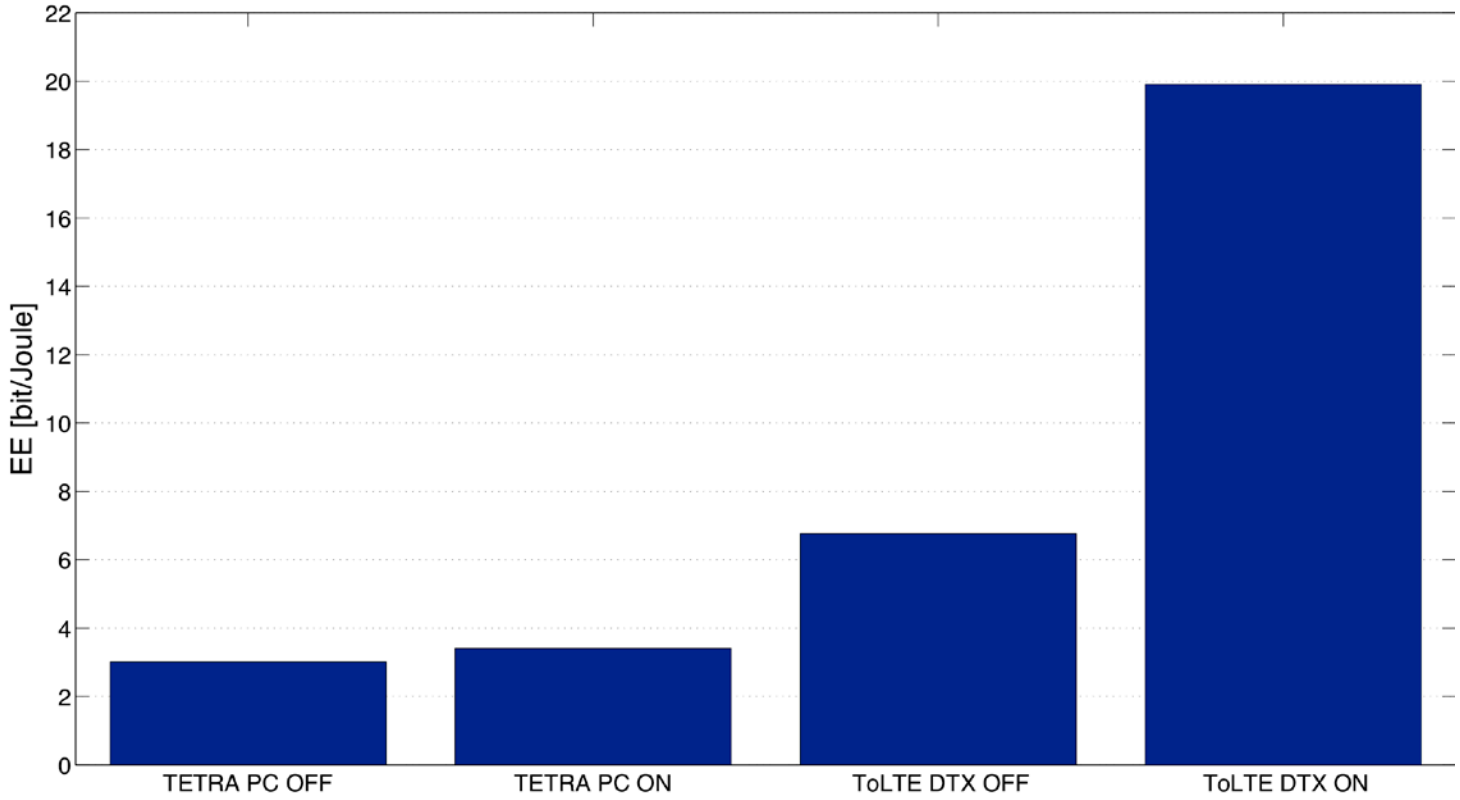
$$\mu_h = \frac{\frac{D_h}{T}}{3600} + \mu_s$$

$\alpha = 4.7$	variable power slope
$P_0 = 210$ W	fixed power consumption
$P_{sleep} = 21$ W	sleep mode power consumption
μ_h	system load
$\mu_s = 0.2$	signaling load
D_h	traffic data delivered during hour h
$T = 0.8Mbps$	maximum allower datarate

TeTRA over LTE cell DTX



Energy efficiency



$$EE = \frac{\sum_h D_h}{\sum_h E_h} \quad [bit/Joule]$$

Conclusion

- A base station power consumption model has been proposed by considering the modules constituting a generic TeTRA BTS.
- Energy saving solutions have been evaluated.
  - The BCCH power control allows the reduction of transmitted power during the no transmission timeslots.
    - Energy efficiency gain without any significant modification in the TeTRA architecture.
  - The transition to the TeTRA over LTE system has been considered
    - Energy efficiency gain due to the hardware improvements and more flexible RRM.

Thank you for your attention!

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