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MACHINE TO MACHINE (M2M) COMMUNICATIONS-PART II

BASICS & CHALLENGES

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Overview

- Introduction
  - Definition
  - Vision
  - Scenarios
- Challenges
- Machine To Machine (M2M) Communications within 3GPP
- Discussion/Summary
- Required Changes To 3GPP Systems
  - Initial Tests Performance

REQUIRED CHANGES TO 3GPP SYSTEMS FOR MACHINE TYPE COMMUNICATION

What kind of changes are needed ?

- LTE & HSPA target Mobile broadband (MBB) access
  - High data rates
  - @ any speed
  - High capable end user terminals, e.g. smartphones, tablets
- Machine type (in the most common initial scenarios) involving
  - Low data rates
  - Low or no mobility
  - cost competitive devices
- **Signaling overhead reduction**
- **Low power consumption**

SIGNALING OVERHEAD

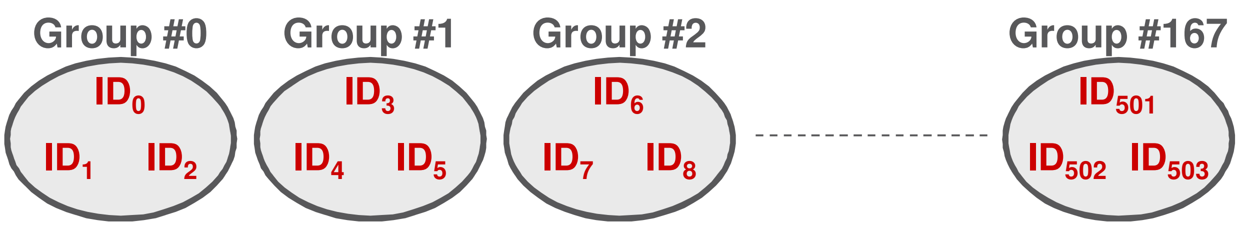
System Functionality

- Cell search/synchronization
- Significant amount of System Information broadcasting
- 6 step approach for random access for connection establishment in case of collisions
- Data Transmissions
  - Scheduling
    - Many options of channel quality reporting, involving extensive reporting options
  - Radio Link adaptation & monitoring
    - HARQ
    - Closed Loop Power Control

Cell Search

- Obtain *identity* and *timing* of candidate cells

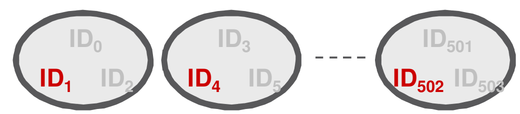
- Physical-layer cell identity
  - Corresponds to a specific reference-signal sequence
    - 504 different reference-signal sequences ⇨ 504 different Cell Identities
  - 168 Cell-Identity groups with 3 Cell Identities per group
    ⇨ 3 RS sequences per group
  - Each cell identity corresponds to a certain RS Frequency Shift



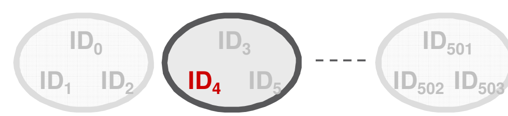
Synchronization Signals

- Two *synchronization signals* transmitted once per 5 ms
  - Two subframes in each radio frame used for synchronization signals

- *Primary synchronization signal* (PSS)
  - 1 of 3 different sequences
  - Provides identity within cell identity group
  - Same sequence in both subframes within a frame
    ➡ 5 ms timing (but frame timing unknown)



- *Secondary synchronization signal* (SSS)
  - 1 of 168 different sequences
  - Provides cell identity group
  - Different sequences in the two subframes of a frame
    ➡ frame timing



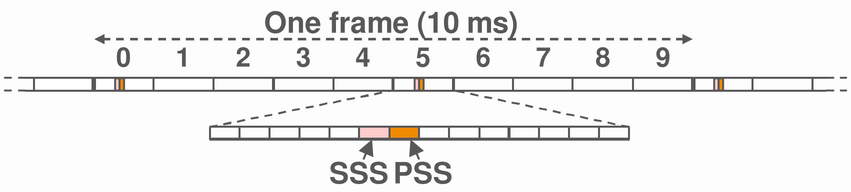
- PSS and SSS detected
  ➡ frame timing, RS structure, PBCH location known
  ➡ possible to read BCH

Synchronization Signals

› Location of synchronization signal differs between FDD and TDD

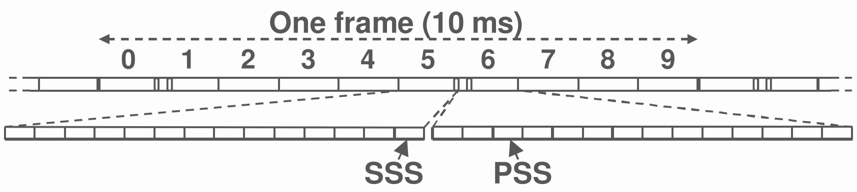
FDD

- **PSS**
  – **last OFDM symbol of slot 0 and 10**
- **SSS**
  – **second last OFDM symbol of slot 0 and 10**



TDD

- **PSS**
  – **third OFDM symbol of DwPTS**
- **SSS**
  – **last OFDM symbol of slot 1**



Synchronization For Machine Type Communications

- Cell search procedure, synchronization sequences and whole channel structure quite suitable for machine type communications
  - At least for the initial synchronization to the system

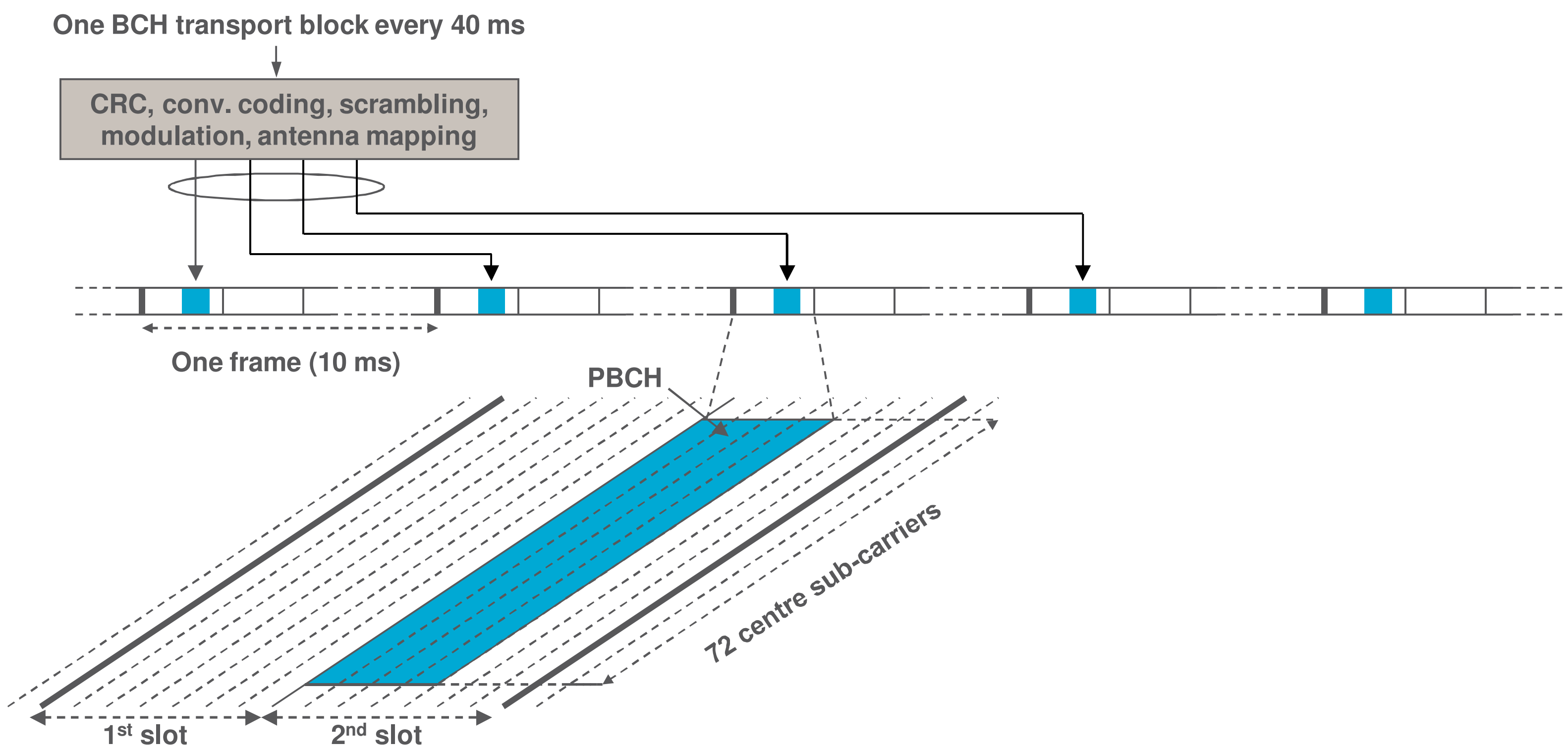
- For stationary devices & for synchronization procedures after the very initial one structures resulting in lower energy consumption in devices can be devised

System Information

- Contains information necessary to access the cell
  - Cell bandwidth, UL/DL allocation for TDD, …
- Master Information Block (MIB)
  - Limited amount of information necessary to read SIBs
    - DL cell bandwidth, PHICH configuration, system frame number (SFN)
- System Information Blocks (SIBs)
  - Main part of system information
  - Organized in SIB1 to SIB16
    - Containing information related to
      - Permission for accessing the cell
      - Random access configuration
      - Mobility related parateters
      - …

Transmission of MIB on BCH

- Special processing compared to DL-SCH
  - Tail-biting convolutional coding
  - 40 ms TTI
  - Not mapped to resource blocks

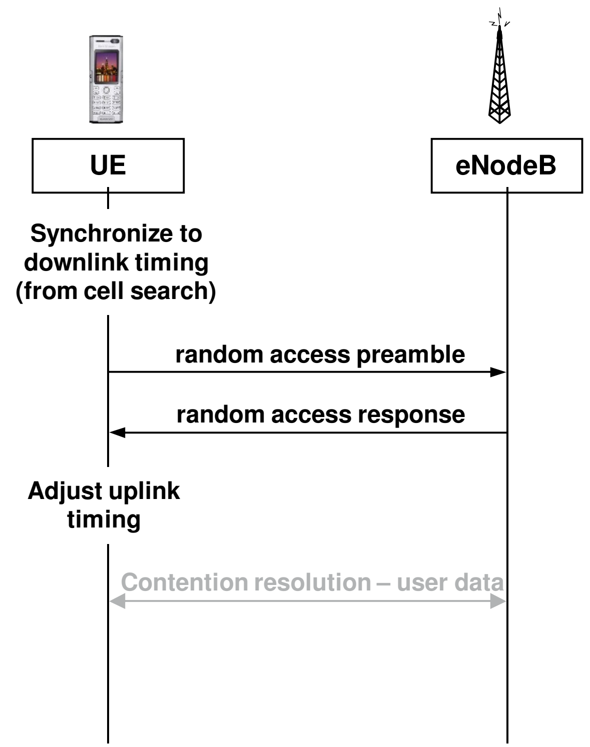


System Information For Machine Type Communications

- System information structure suitable for machine type communications as well
- For stationary devices probably most of system information not useful
  - E.g. related to mobility
  - "Lighter" version of SIBs might be devised

Physical Random Access Channel *PRACH* – principle

- For case the UE does not have any dedicated resource (i.e. initial access and re-synchronisation), access is done on a common resource, PRACH, to acquire:
  - Uplink time alignment
  - Dedicated resources
- To minimize the signalling on common resources only a preamble sequence on PRACH
  - Data is not transmitted on PRACH only on PUSCH
  - If eNB detects preamble sequence it provides dynamic resources for data transmission on PUSCH
  - Potential collisions are resolved by higher layers



PRACH – physical resource

- Time
  - Basic duration is 1 ms in time duration
  - Time and frequency location provided as part of system information
  - Scheduler can avoid scheduling data on PRACH resources
- Frequency
  - Bandwidth of 6 RB

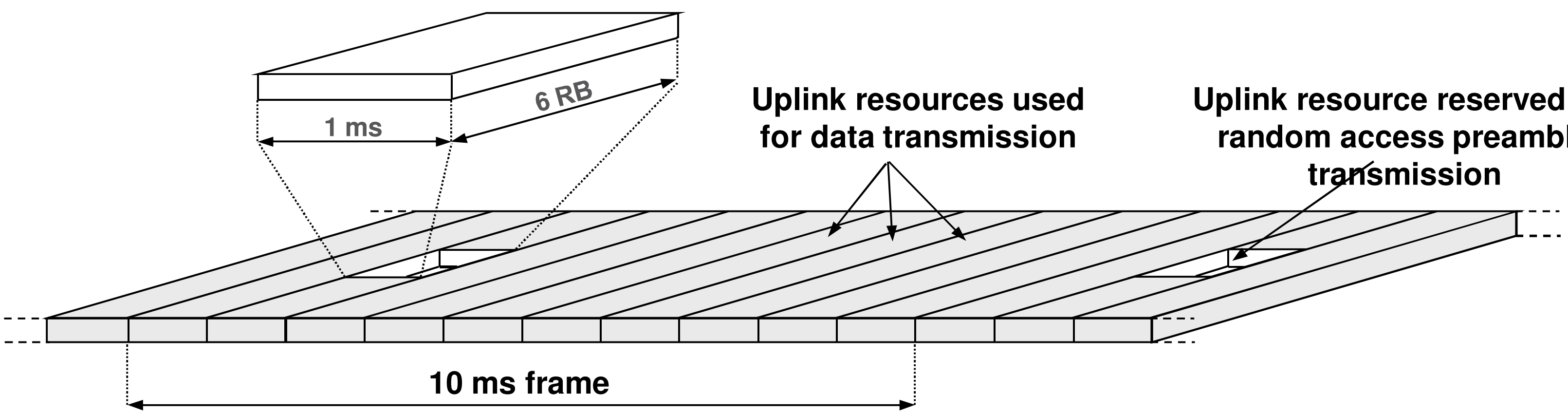
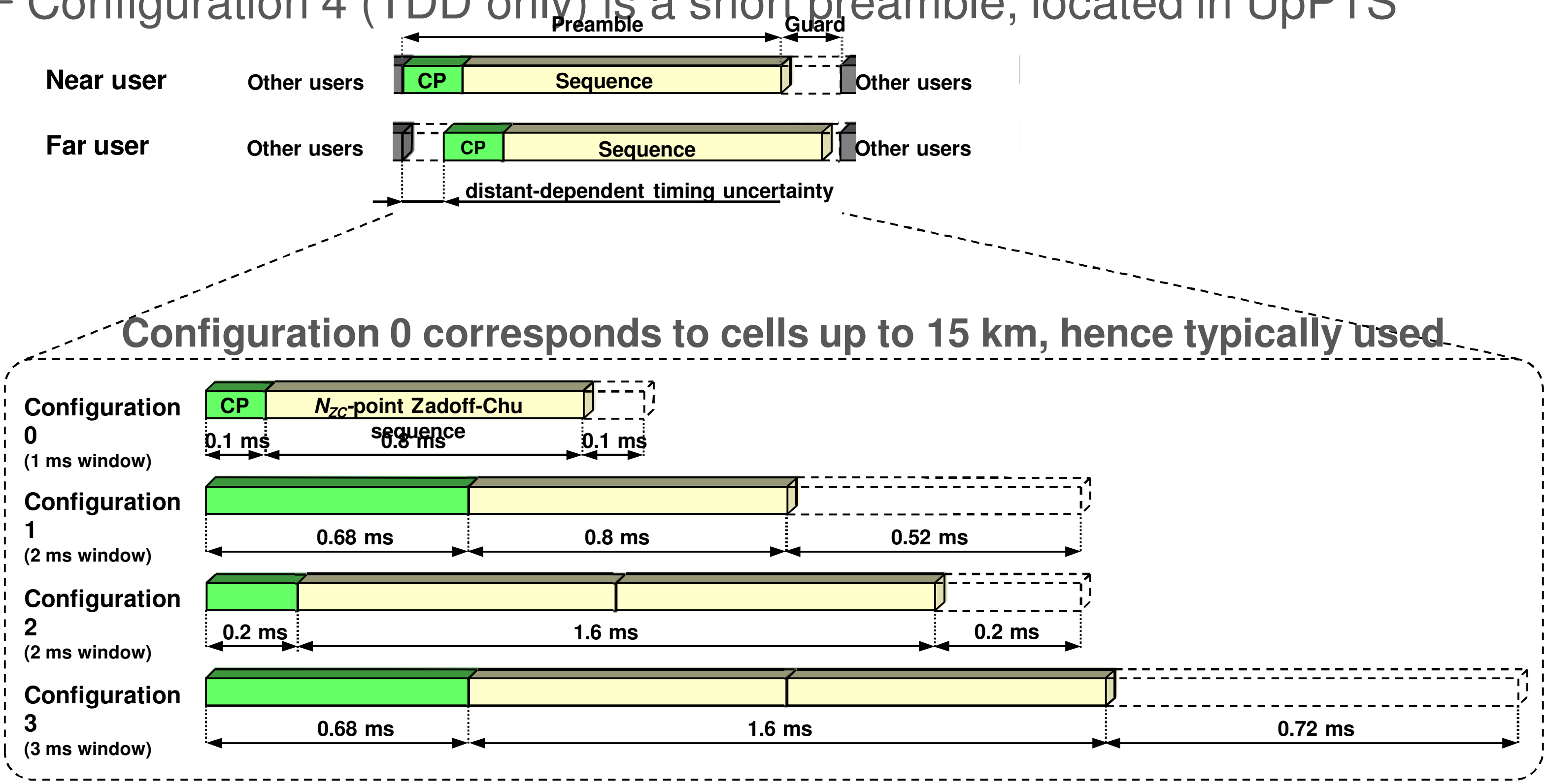


Figure illustrates configuration 0-3. For TDD, configuration 4 available in addition, locating PRACH in UpPTS.

PRACH – Preamble Formats

- Preamble consist of two parts
  - Preamble format
  - Cyclic shift
- Different configurations supported to handle different deployments
  - Configuration 0-3 shown below
  - Configuration 4 (TDD only) is a short preamble, located in UpPTS



Random Access For Machine Type Communications

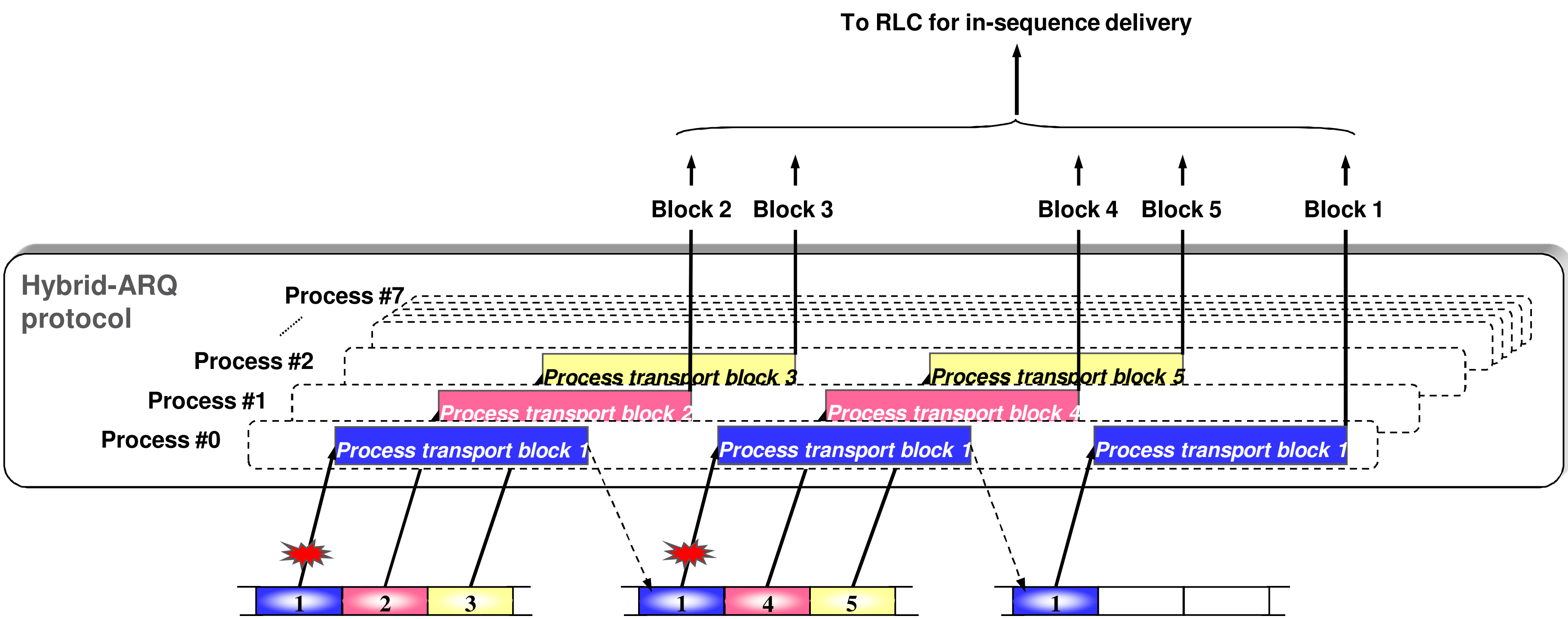
- Current channel structure and sequence structure rather "heavy" also applicable for machine type communications

- Reduction of the number of messages exchanged to establish a connection

- Use RACH for transmitting data as well, could be another option

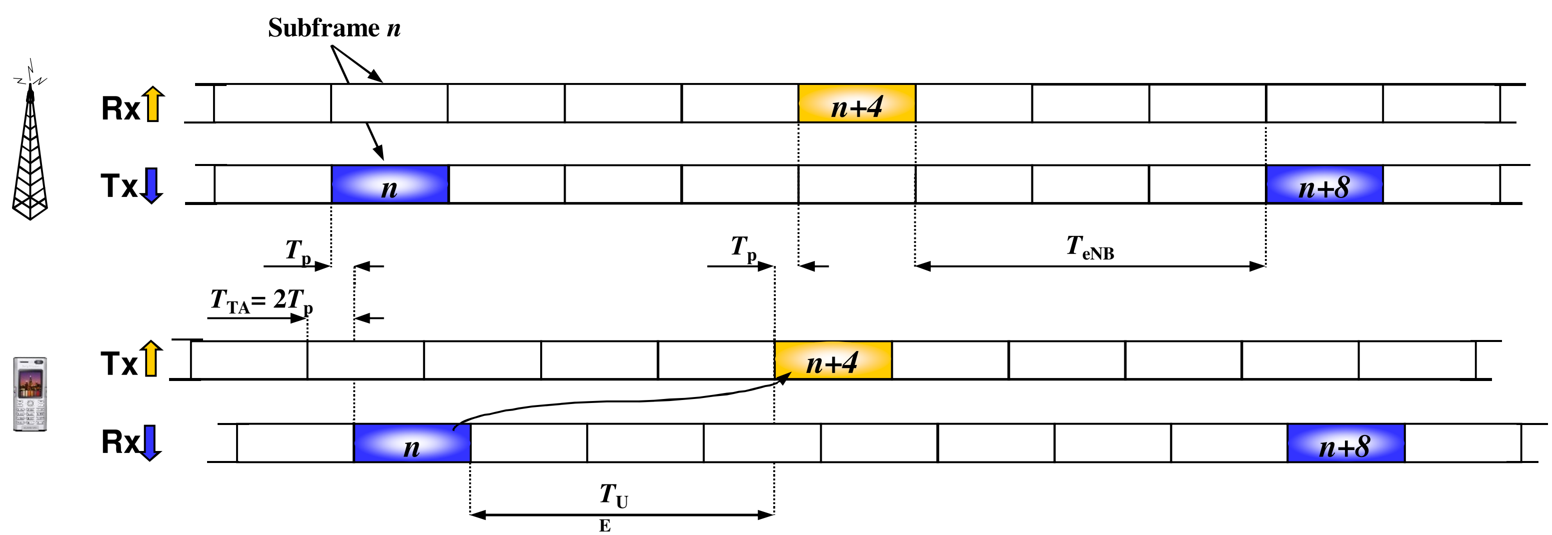
Hybrid-ARQ with Soft Combining

- Same basic structure as HSPA
  - Parallel stop-and-wait processes
  - 8 processes ➡ 8 ms roundtrip time (for FDD)
- Incremental redundancy (through rate matching mechanism)
  - Support for chase combining and incremental redundancy
- More details in L2 presentation



Hybrid ARQ – FDD

- 8 hybrid-ARQ processes
  - One-to-one mapping between downlink and uplink subframes
- Soft buffer size depends on UE category
- ~3 ms processing time in UE and eNB
  - UE need to handle up to 100 km cells ➡ ~2.3 ms processing time



HARQ For Machine Type Communications

- Current channel HARQ procedure involves
  - Fast feedback mechanism
  - High speed processing
- No direct fit to traffic type expected within MTC
  - High signaling overhead for the expected benefits
  - Requires high processing power
- Simplified feedback schemes can be devised, especially for stationary devices
- Partial HARQ use another option

Uplink Power Control

- Closed-loop power control around open-loop setpoint
  - Separate loops for PUSCH and PUCCH

- Two possibilities for sending power-control commands
  - Part of scheduling decision

  - Separate power-control command

Uplink Power Control – PUCCH

- **Cell-specific**
  - part of system information
  - to control received SIR for PUCCH
- **To handle different SIR requirement for different PUCCH formats**
  - Table given in spec

$$P_T = \min\{P_{max}, P_0 + PL_{DL} + \Delta_{Format} + \delta\}$$

- **Measured pathloss**
- **Power-control bits (accumulation)**
  - Part of downlink assignment, -1,0,+1+3 dB, ...
  - ...or separate power-control command, -1, +2 dB

Uplink Power Control – PUSCH

- **Scheduled PUSCH bandwidth**
  - **control *power spectral density* (power per resource block)**
- **To handle different SNR requirements for different MCSes**

$$P_T = \min\left\{P_{\max}, P_0 + \alpha \cdot PL_{DL} + 10 \cdot \log_{10}(M) + \Delta_{MCS} + \delta\right\}$$

- ***Fractional* pathloss compensation**
  - **0 (no pathloss compensation), 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1 (full pathloss compensation)**
- **Power-control bits**
  - **Accumulation can be configrued on/off**
  - **Part of uplink grant, -1,0,+1+3 dB, ...**
  - **...or separate power-control command, -1, +2 dB**

Uplink Power Control For Machine Type Communications

- Current power control mechanism involves
  - Fast feedback mechanism
  - High speed processing

- Considering
  - the low amount of traffic involved in these applications and that
  - machine type devices are stationary

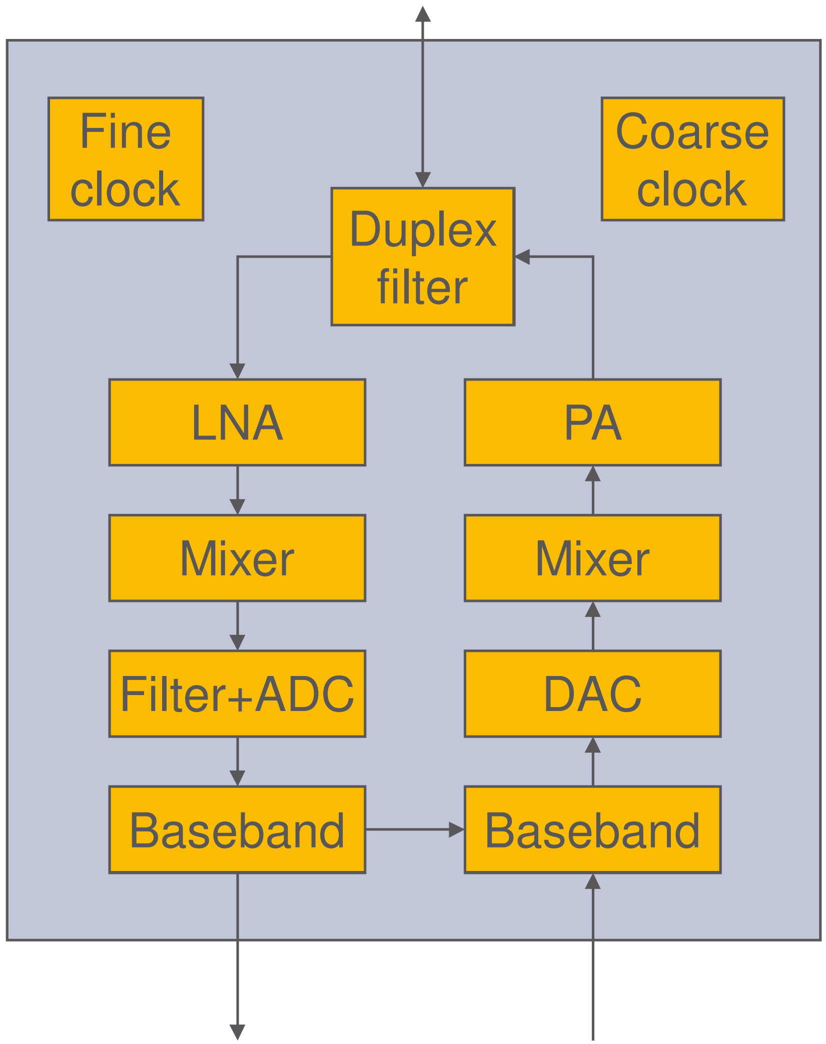
  uplink power control is quite "heavy" for MTC

- Solutions with constant transmission power levels can be imagined

POWER CONSUMPTION

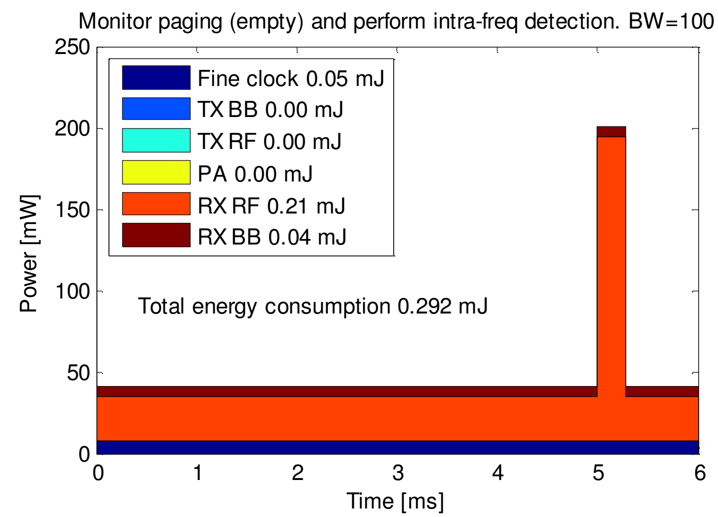
Power Consumption Model

- Detailed model developed
  - Based on UE function blocks
  - Applicable to HSPA and LTE
- Influencing factors
  - Activity time (each block)
  - Output power
  - Bandwidth
  - Bitrate
- Assumptions in this study
  - Aggressive optimizations for sensor device type

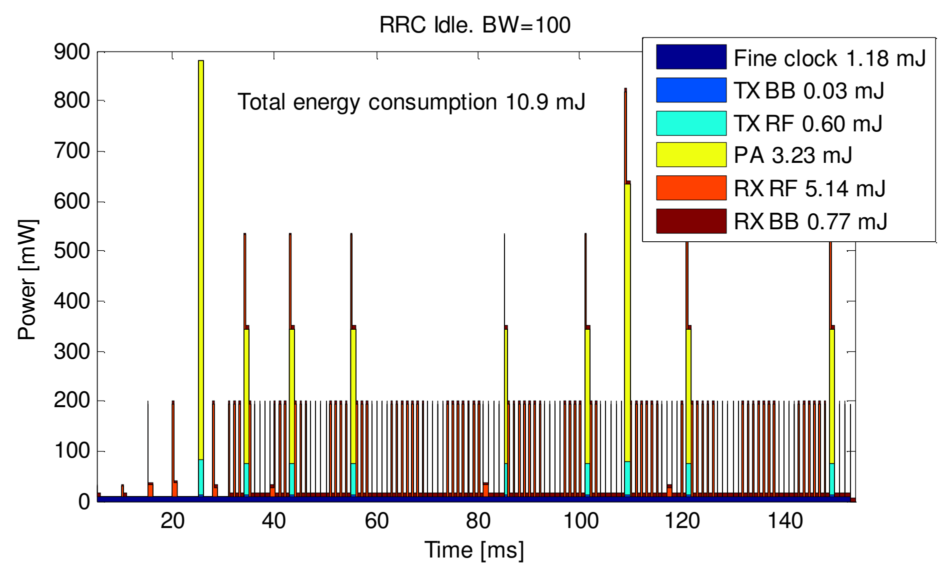


POWER Consumption Examples

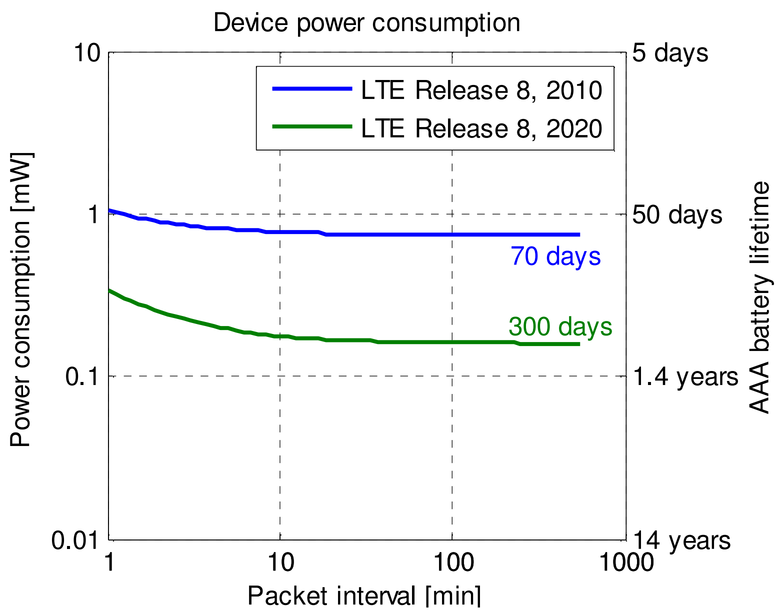
- IDLE mode power consumption
  - Paging monitoring
  - Measurements
  - Periodic tracking area updates



- Connected mode power consumption
  - Connection setup signaling
  - Uplink payload
  - Connection release signaling



POWER Consumption 3GPP LTE release 8



- Inactive periods dominate energy consumption
  - Except for very short packet intervals
- Packet size 100 B
- Battery lifetime less than a year

Summary/Discussion

- Challenges related to introduction of machine type communication to 3GPP
- 3GPP systems not devised for this type of communication
- Considerable engineering work required

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