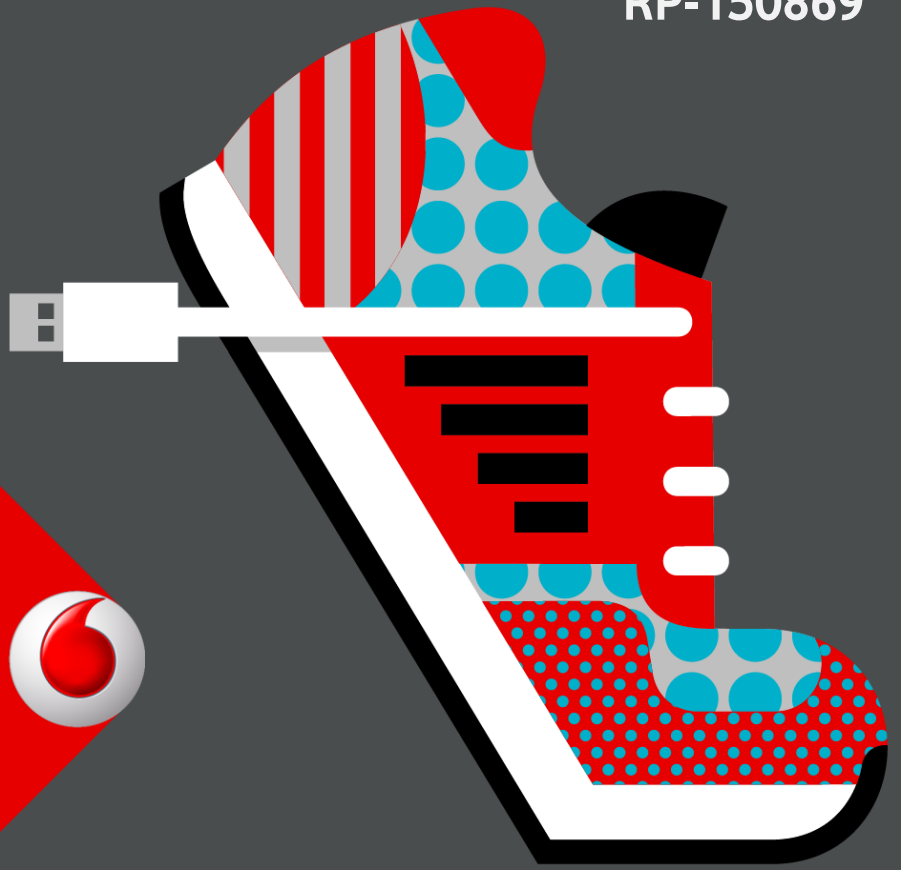
RP-150869

Cellular Internet of Things: architectural aspects



Vodafone

3GPP RAN#68, Malmo, Sweden

Gb or S1 based architecture:
Objective from SID in GP-140421*

- Identify Core Network Architecture, security framework and Radio Access Network-Core Network interface (e.g. S1 or Gb), and associated protocol stacks, suitable for the M2M market in the 2017 and onwards timeframe. Restrict use to a simple QoS model (e.g. equivalent to the R'97 peak bit rate and precedence, or, R'8 AMBR and QCIs 6, 8, 9 but with a relaxed packet delay budget); single PDP context per MS; etc.). Potential enhancements within the responsibility of other groups may be identified.

  - There is no requirement for inter-RAT mobility.
  - Intra-RAT mobility is assumed to be based on cell reselection.

* latest version of SID is in GP-150354

Why compare Gb and S1?

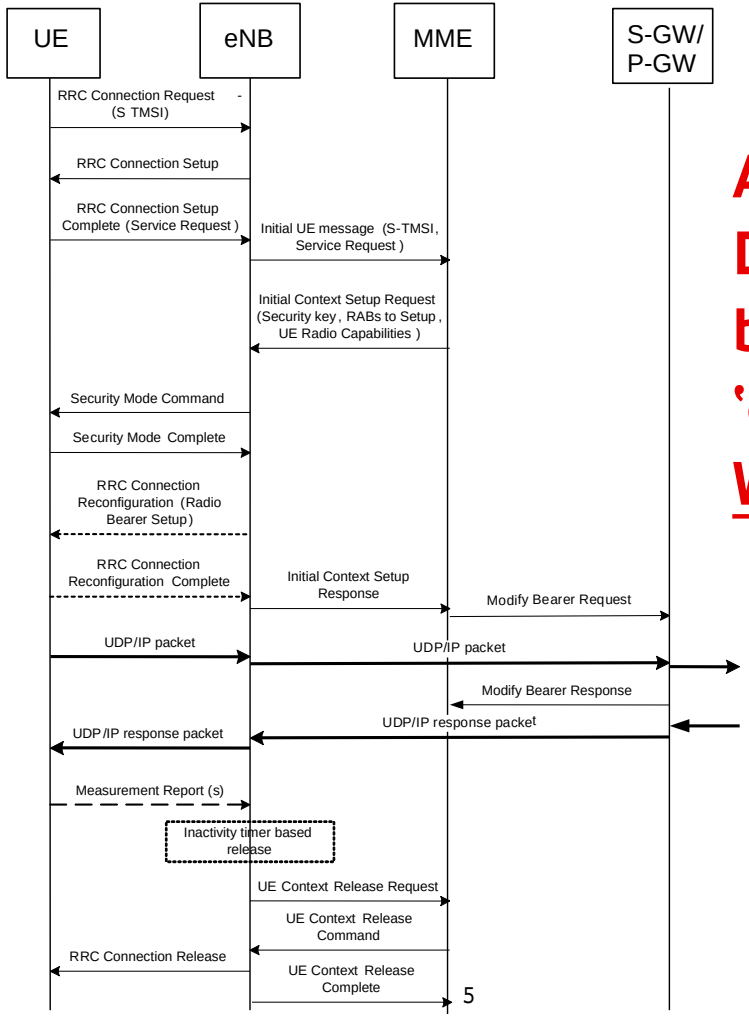
- May 2014 -> redesigning architecture not feasible
  - SA2 overload
  - no normative WID for CIoT

- June 2014 -> SA2 SID on "lightweight core network" unlikely to produce CRs in R'13

- Gb or S1 or Iu?
  - Gb selected for GSM evolution concepts
  - Iu rejected
  - Gb and S1 comparison ongoing

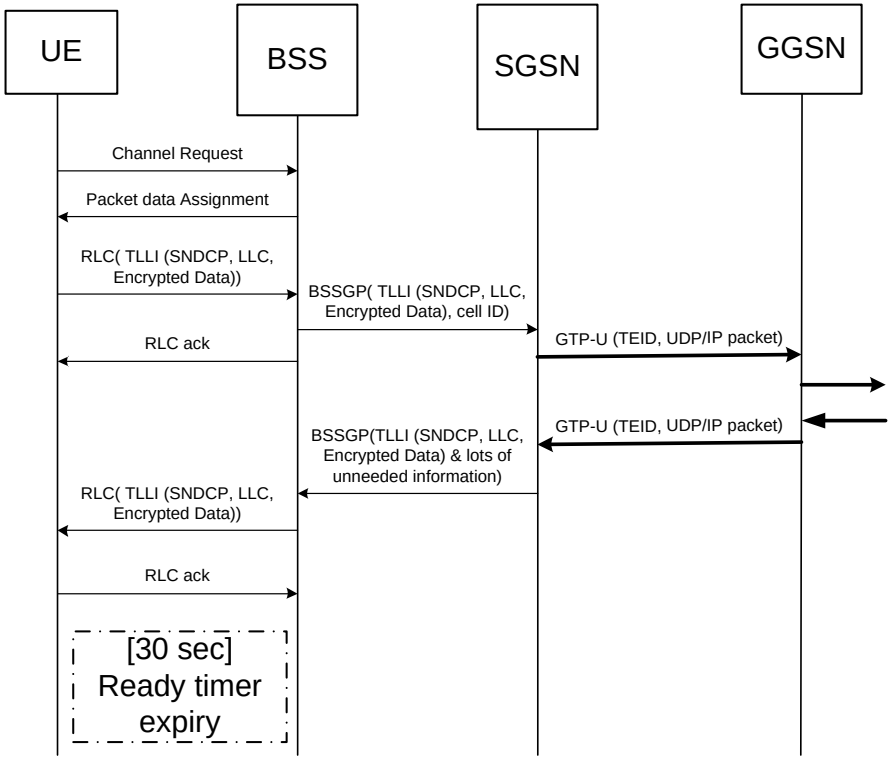
Transmission efficiency

- message flows for an IP packet pair
- battery life



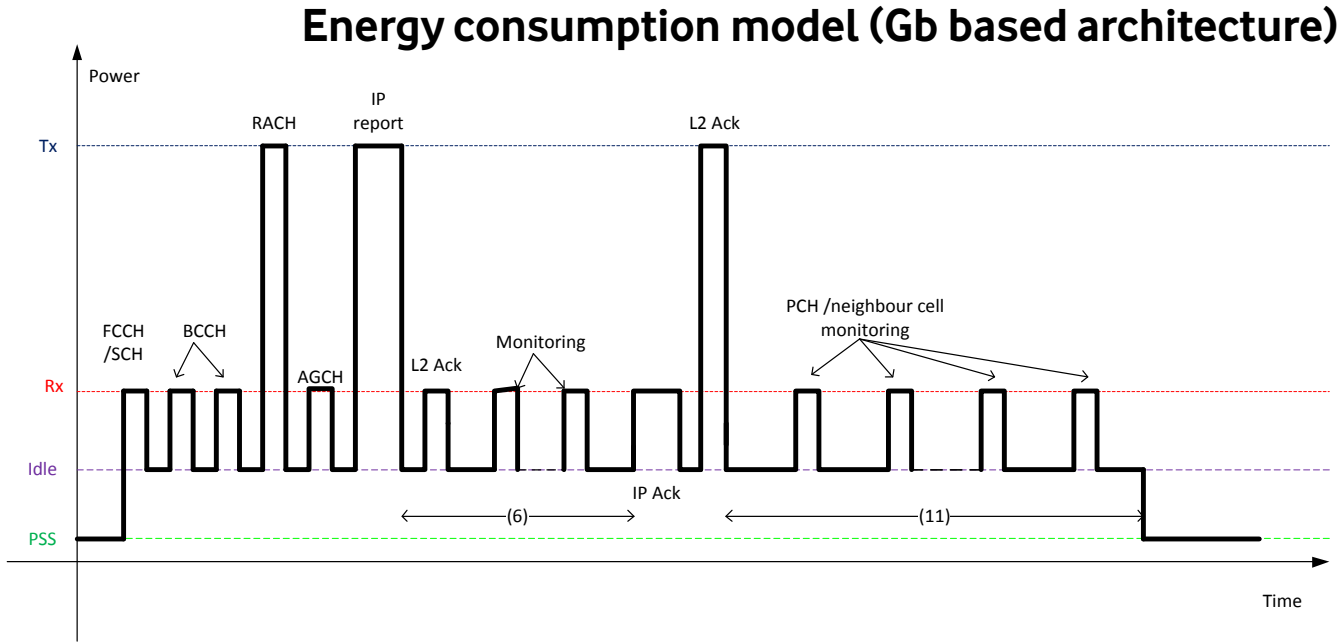
Acknowledged Datagram transfer on S1 based architecture for 'clean slate'. Without L2 acks

Acknowledged Datagram transfer on Gb based architecture for Clean Slate (with L2 acks)



Battery Life

- 10 year battery life with 5 W Hour battery, at GSM+20dB, and 200 bytes/day just feasible.



TR 45.820 battery life analysis

- based on Gb interface
  - to enable comparison of radio proposals
- assumes use of R12 Power Save Mode
  - Periodic RAU timer > data report interval ➔ no signalling
- RoHC IP header compression active
  - runs between SGSN and UE in Gb mode: context maintained in Standby state (=*Idle*)
  - with S1 interface, PSM requires drop to RRC Idle
  - at RRC establishment, no RoHC context in UE or eNB

  → no header compression for first IP packet pair on S1
- Minimising transmitted bytes important at extreme coverage
  - avoid RRC establishment/release signalling, and uplink acks for L3 messages
- Note: no Power Save Mode/SMS Message Waiting functionality in RRC-connected

Core network “size & shape”

Data Throughput of CIoT Core Network:

Example from TR 45.820 section 8.1.6

- 17500 base station sites in network
- 3 cells/site
- 52547 devices/cell (Annex E.1)
- extend as a uniform device density in all cells in network
- data throughput of 50 bytes per device every 2 hours,

➔ mean CN user plane throughput of approx.150 Mbit/s for the complete network.

- Contrast with peak data rate of a single LTE Cat 4 device (LTE Rel 8) of 150 Mbit/s or a single LTE Cat 6 device (2 downlink carrier aggregation) of 300 Mbit/s.

Signalling Load in CIoT Core Network

Example from TR 45.820 section 8.1.6

- 40 devices/household
- 2 people/household
- 60 million people/country

→ 1.2 billion devices/country

- One transaction per device per day
  - daily report, or, heart beat periodic update for MT traffic in Power Save Mode

➔ Approx. 14 000 transactions/second

- Roughly equivalent to 2.5 million LTE devices connecting/releasing every 3 minutes

➔ Control plane efficiency is important for the CIoT Core Network.

→ CN nodes need to support large numbers of low activity devices

Latency and NAS timers for CIoT

- 160 bit/s at extreme coverage
- 80 byte NAS message (e.g. Attach Request) → 4 seconds on radio interface

➔Radio interface latency makes virtualised Core Network attractive

➔NAS timers in UE and SGSN/MME need relaxation

Other aspects

Other Aspects of Gb vs S1 comparison (1)

- Soft Paging area boundaries
  - TAI list supported on S1 but no equivalent on Gb based system.
- SMS support
  - e.g. for management of preferred roaming partner list on USIM
  - Gb -> SMS native on SGSN
  - S1 -> "SMS over SGs" ➔ MSC for CIoT
    Note: "SMS in MME" designed for operators without 3GPP 3G/2G
- Attach without PDP context?
  - possible on Gb but not S1
- Efficiency improvements from Non-IP PDP context/bearer?
  - Gn/Gp SGSN support likely (SGSN fragments IP packets to smaller LLC frames)
  - may be difficult with S-GW and eNodeB that can be "IP aware"

Other Aspects of Gb vs S1 comparison (2)

- Mobility
  - Gb uses UE led mobility
  - S1 is network controlled mobility
    - mobility via Radio Link Failure impacts use of MME counter
- Security of Gb based architecture
  - UMTS AKA supported and used on 2G
  - GEA 4 available
  - new RAT → can ban use of weaker algorithms
  - SA3 work ongoing - needed for Evolved GSM concepts
- BSC or "Flat RAN"?
  - Gb can support flat RAN
  - S1 can support eNB with many cells

Combined MME/SGSN

- Many vendors support combined nodes
- section 5 of GP-150518 (GERAN #66) contains URLs and extracts from some vendor websites
- Natural separation of counters/timers for LTE MBB and CIoT.

Shared MME for CIoT and Mobile BroadBand

- Counters/statistics may need separation based on device type
- EMM/ESM timers need to be relaxed for CIoT but not MBB

- MSC dimensioning for each attached CIoT device (for SMS over SGs)

Migration from CIoT "launch" Core Network to "lightweight core network"

- "Gb-flex"/"S1-flex" supported by CIoT
- Once UE is attached, CN node is selected by eNB based on part of P-TMSI/S-TMSI
- In R'13 CIoT: provide additional "RRC establishment causes" in RACH for Signalling messages:

Random Access Establishment cause	meaning
000	Data transfer/service request
001	response to paging
010	signalling to R12 Core Network
011	signalling to R13 Lightweight core Network

- Signalling gets routed to correct core network type.
- TMSI ranges divided up between CN node types
- CN node allocates TMSI from correct range for later data transfer

Summary

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- Gb architecture natively optimised for transfer of pair of small packets
  - radio capacity
  - battery life
  - core network signalling load
- Significant S1 architecture changes needed to match Gb architecture
- CIoT core network "size and shape" vastly different to that for Mobile BroadBand
- CIoT latencies favour virtualisation of Core Network
- Small scale CIoT launch? -> significant vendor support for combined MME/SGSN
- Migration from R12 CN to future lightweight CN possible with sensible R13 CIoT design