WINTECHCON 2018

September 28, 2018

Context aware methods for uplink centric Narrow Band IoT Devices

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Problem Statement

- Cellular communication is a great enabler for Internet of Things (IoT), as it offers coverage, quality of service and most importantly the maintenance and operations is centralized and taken care by the operator
- Narrowband IoT (NB-IoT) is designed by 3rd Generation Partnership Project (3GPP) for a plethora of use cases which cater to broad spectrum of capabilities but introduces few in-efficiencies in the resource allocation and adds overhead in the system.

i. Command-response traffic (triggered reporting), having latency of 10 seconds.

ii. Exception reported by IoT module having latency of 1.6-3 seconds.

iii. Periodic reports or Keep alive, insensitive to latency.

→ IoT modules are use case centric (to solve a specific problem) and not general purpose like smartphones/mobiles.

- A generic protocol design leaves sub optimal choices for a specific use case.

Problem Statement

- We analyzed the behavior of activity trackers especially for kids and seniors requiring assistance and found that such devices access network based on events generated within the device; broadly classified as ‘uplink-centric’.
- We classified the devices under two major buckets from use case perspective.

(a) “Delay tolerant Mobile originated data”, or (use case (iii) – Periodic reports)

(b) “Emergency information data”, or (use case (ii) – Emergency reported)

→ ‘use case’ or context aware network; protocol design for uplink centric devices within the NBIOT LTE/3GPP framework.

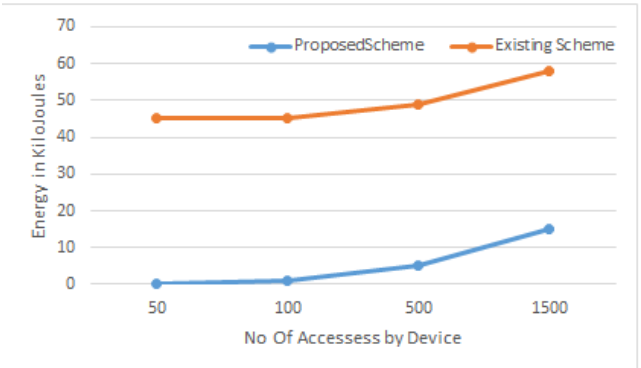
Solution Approach : Ultra-Deep Sleep

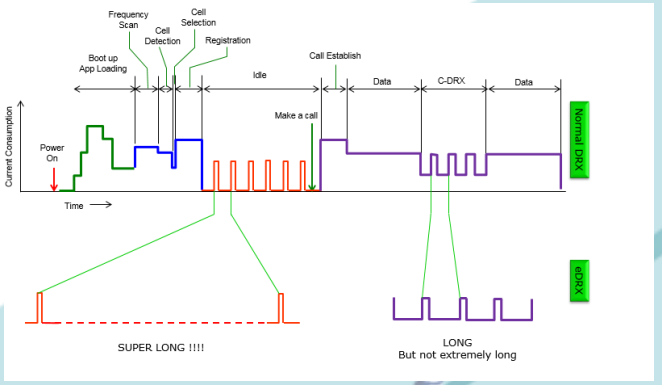
- In Idle mode, it is not necessary for the MTC device to monitor paging, consequently, there is no need to follow DRX cycle viz. seep and wake up procedure. Device selects a cell, just before uplink operation, thus it does not need to perform measurements/re-selections.

→ Removal of DRX and cell re-selection enables huge power saving in idle mode as device goes to ultra-deep sleep and shuts off its modem/RF/processor.

→ It wakes up again based on the explicit trigger from the sensors or interface.

→ This lowers the bottom-current by almost 90%, and improves the standby battery life to nearly a week for the device as captured in below Fig (based on estimated targets from [7]).





Context Based Cell Search(System Acquisition) (1/2)

- As per use case, the device would most likely be in similar premises (restricted locations during the day), like a home or office, so a network access may happen on a known network every time. The accesses will be profiled based on time or location, and can form a context database on the device, Table1. The context forms on historical acquisition and adapts as the device ages.

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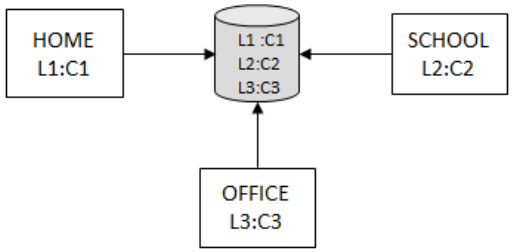
Context	Time	Location	Network
#1	T=T1	L=L1	{Cell-1, PLMN-1, RAT-1, TA-1,UL-TxPow-1, PUSCH_pow-1, PUCCH_pow-1 }
#...	….	….	…
#N	T=Tn	L=Ln	{Cell-n, PLMN-n, RAT-n, TA-n,UL-TxPow-n, PUSCH_pow-n, PUCCH_pow-n}

Context Based Cell Search(System Acquisition) (2\2)

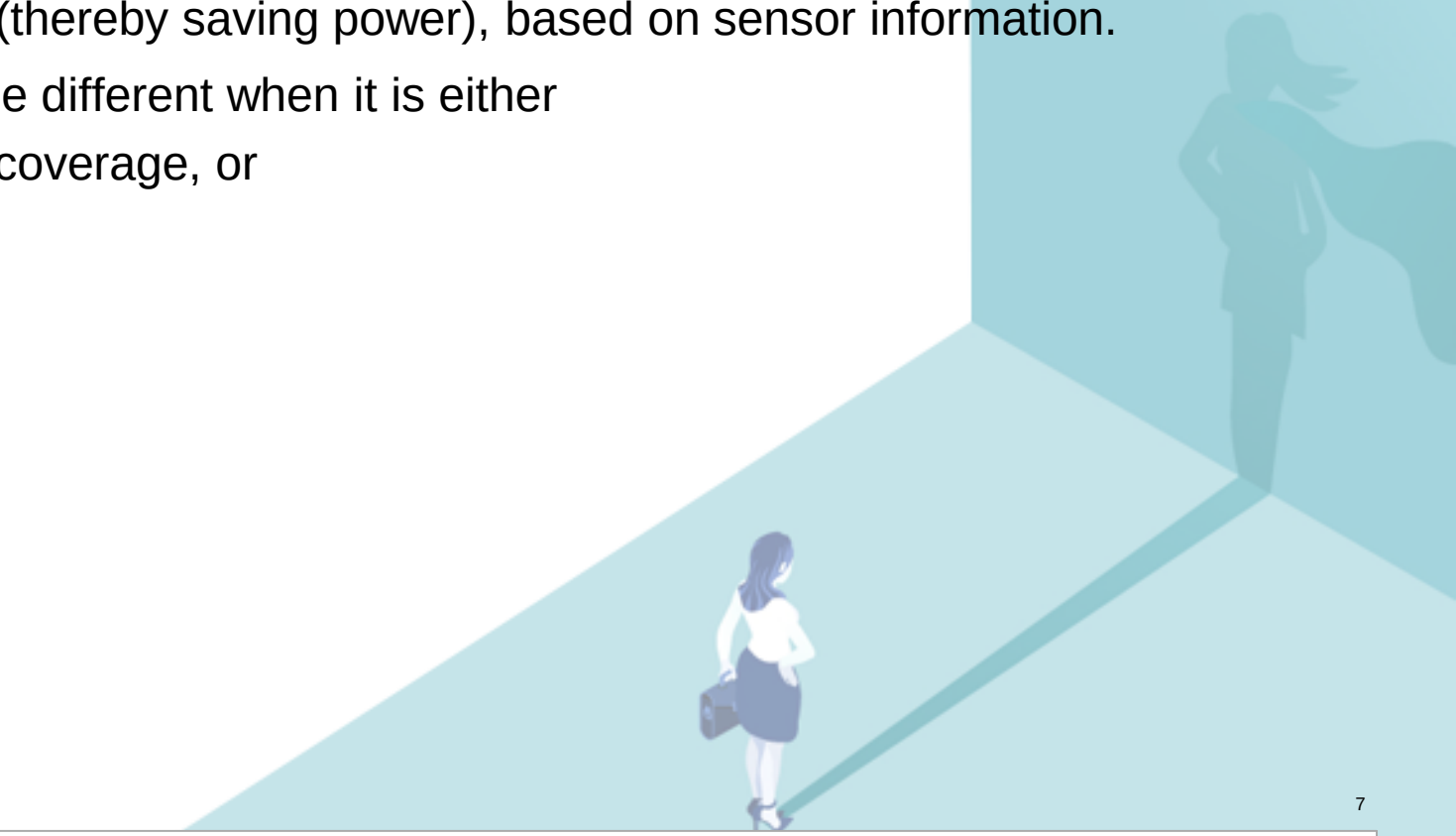
- Device should follow two-step search procedure, whenever there is a trigger to access the network
- Step-1: Search as per current context
- Step-2: If Step-1 fails, fallback to 3GPP behavior for cell search and acquisition

- The location can be reference based on serving cell and neighbor cell measurements.



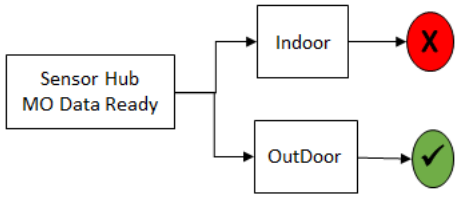
Context based Scheduling (1\2)

- For a Delay tolerant use case, the device can initiate network access, when it calculates that the channel compensation is lowest (thereby saving power), based on sensor information.
- The channel compensated can be different when it is either
  - Outdoor leading to maximum coverage, or
  - NW load is relatively load.

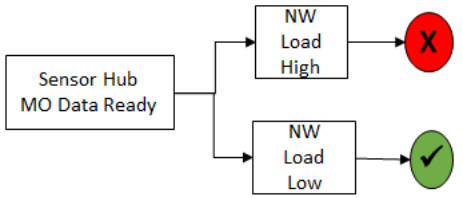


Context based Scheduling (2\2)

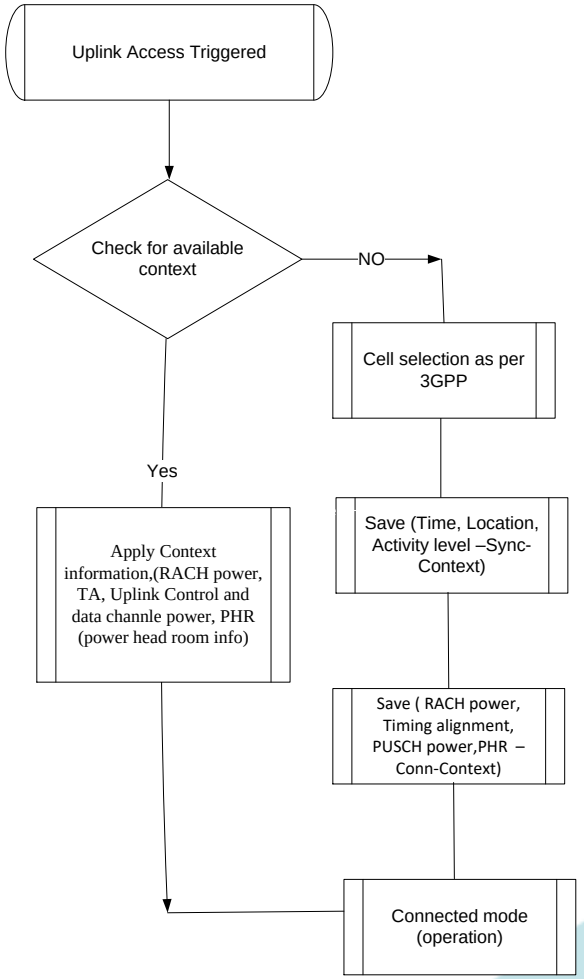
For example, if the device is static and outdoor it can access the network, as shown in below figure



Network may also configure an appropriate time when the device accesses it, based on traffic loads expected during that time, as shown in below Figure



Context Based Cell Search and Scheduling Flow



Machine Type Semi persistence scheduling (M-SPS)

Once Step-1 search is successful, based on the context, coarse level information for Timing alignment (TA), and UL transmit power (UL-TxPow, PUSCH_pow, PUCCH_pow), is available. This minimizes the need of random accesses channel (RACH).

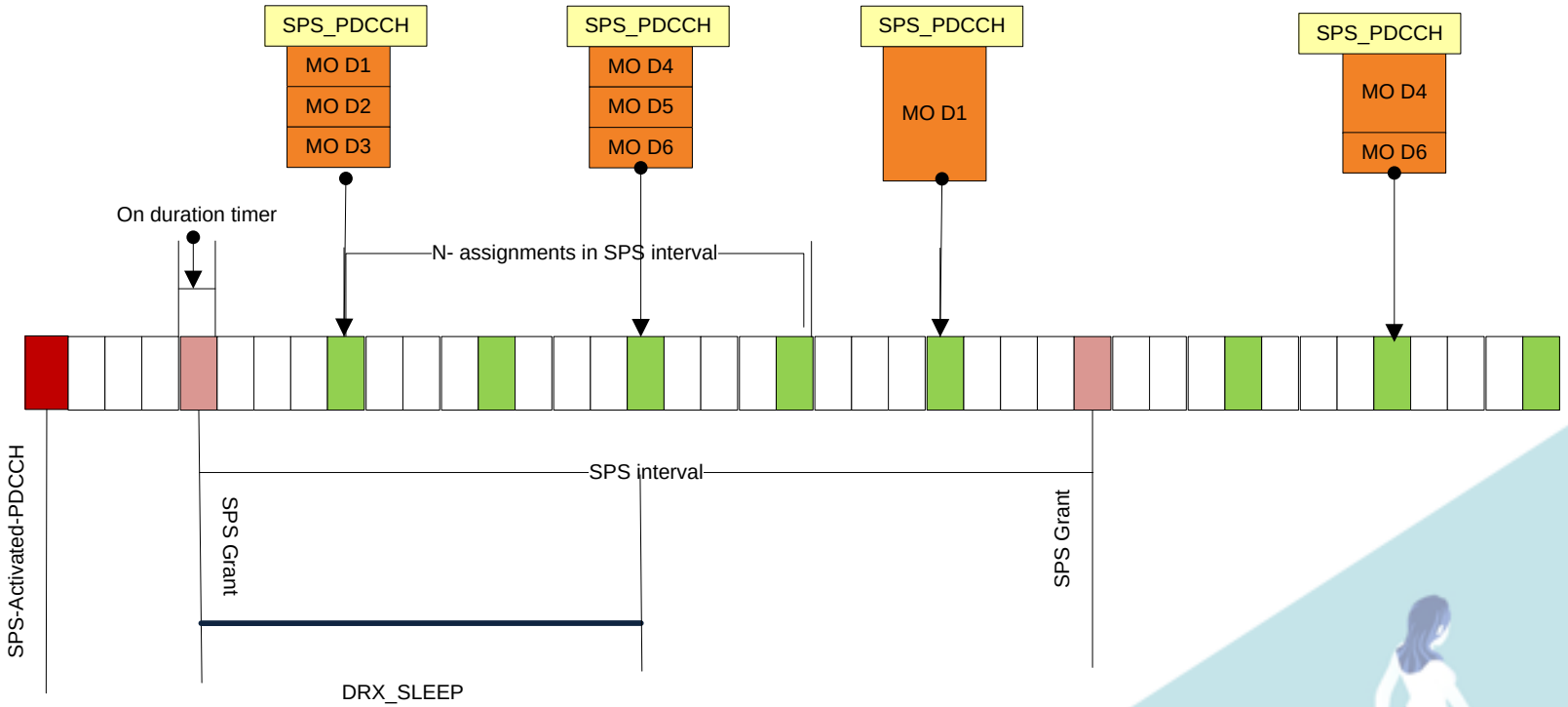
→ Pre-allocated resources (SPS) across all MTC-uplink centric devices is shared using time domain multiplexing.

→ Devices having similar or integer multiple of scheduling interval will be grouped together.

→ As shown SPS_PDCCH at every SPS scheduling period indicates the resources for the scheduled UEs from within the same group.

- However, if Step-1 search fails, then 3GPP defined RACH procedure is performed, so that UE can be allocated a new group and corresponding SPS resources at the selected cell; the group or SPS in the previous cell will be released through backhaul signaling.

Machine Type Semi persistence scheduling (M-SPS)



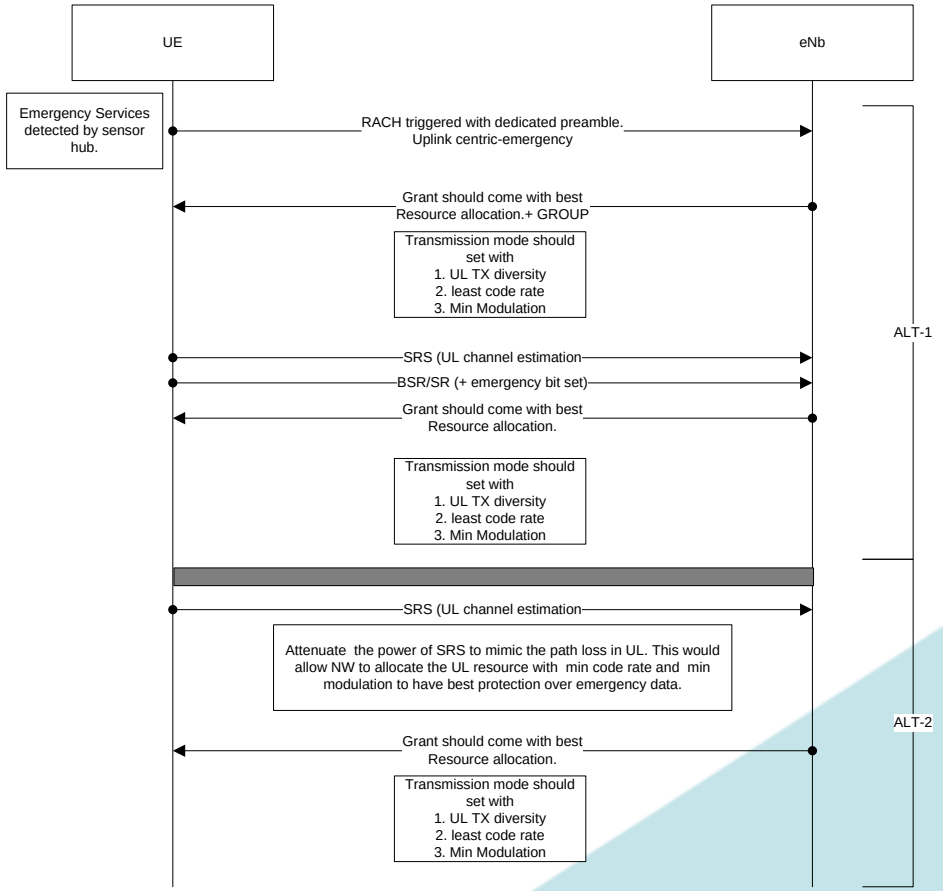
Emergency Access

- During emergency access the communication is expected to be highly reliable and with minimum latency. We propose to have cross layer optimization, where emergency service would trigger the uplink data with highly reliable radio link entity.

- *Alternative-1 (Network aware):* Logical link entity established for the emergency service indicates to the network of the emergency nature of the service. Thus, network with then allocate the UL resources with maximum redundancy and minimum modulation with additional frequency, time diversity (or coordinated multipoint transmission resources).

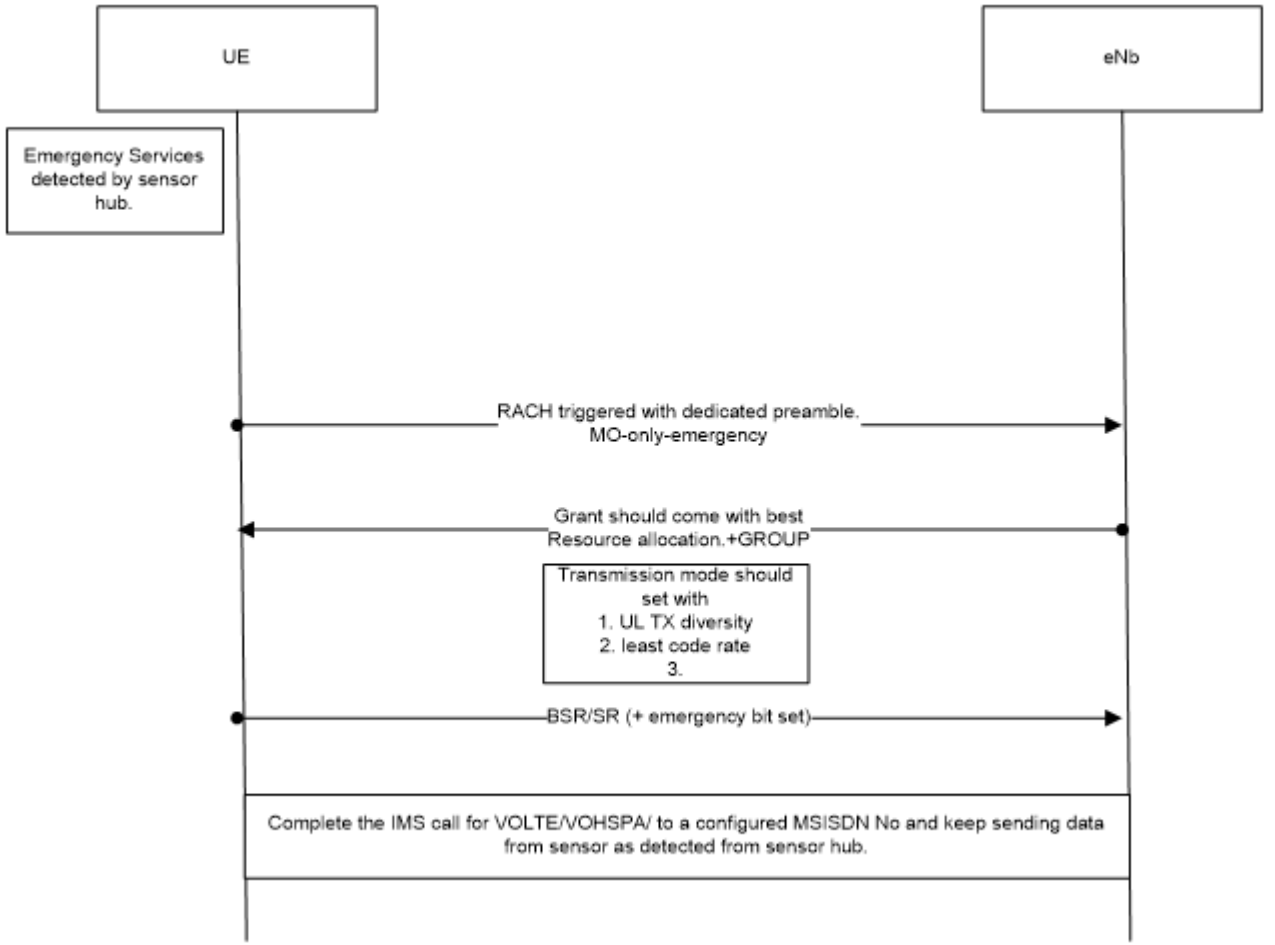
- *Alternative-2 (Network Un-aware):* Device minimizes the sounding reference signal power, in order to mimic path loss, which would eventually provide resources with maximum protection and minimum modulation with additional time and frequency diversity (transmission modes).

Emergency Access Flow



Emergency call to configured MSISDN

Emergency Service for uplink centric devices



Conclusions

3GPP LTE and Narrow Band IoT proponents optimize their network primarily to satisfy low throughput requirements and leverage the delay insensitive nature of the expected NBIoT traffic. Knowledge of use cases is under-utilized both at the device and at the network side.

IoT devices for specific purposes, unlike normal mobile terminals, open up new areas for optimization.

A use-case aware network improves the resource utilization, optimizes the power consumption, and adopts robust communication for emergency scenarios.

We present algorithms and protocols, which shows huge gains over traditional systems by over 80% in resource allocation (through group based SPS) and over 90% in power consumption (through removal of DRX and measurements).

References

- TR 36.888 v12.0.0, “Study on provision of low-cost Machine-Type Communications (MTC) User Equipments (UEs) based on LTE (Release 12)”, June 2013
- Qualcomm, Optimizing LTE Advanced for machine-type communications to connect the Internet of Everything
- https://www.qualcomm.com/invention/technologies/lte/mtc (2014)
- US8755825, Method and apparatus for supporting machine-type communications with a mobile-originated-only mode
- http://www.google.com/patents/US8755825 (2014)