Role and Evolution of Radio Network Controllers

Pekka Varis

Senior R&D Manager / Senior Specialist
Nokia
pekka.ju.varis@nokia.com

NOKIA

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Agenda

- **Radio Network Controller (RNC) General Summary**
  - 3GPP WCDMA (UMTS) network background and architecture
  - Radio Network Controller
- **RNC Technical Functionality**
  - Control plane and User Plane
  - Key Elements of User Plane
  - Dynamic Behavior of Packet Switched Calls
- **Evolution of RNC**
  - Drivers
  - Distributed or Centralized
  - Scalability

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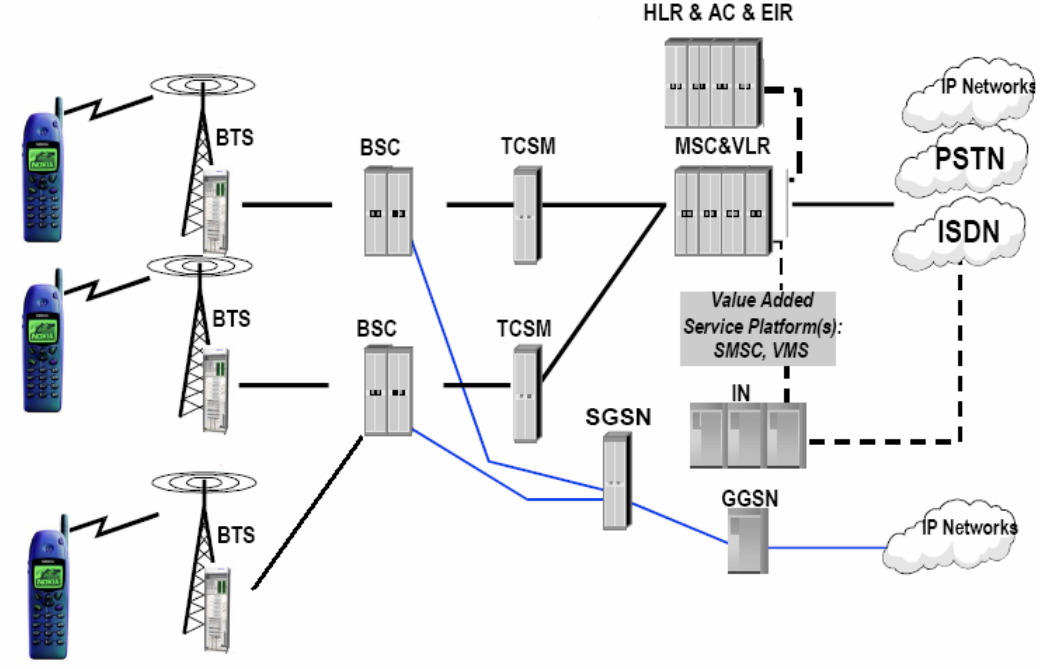
Basic GSM Network



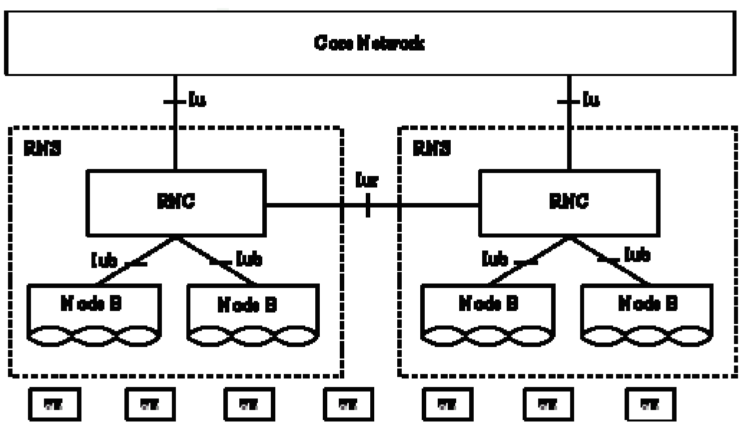
- **Base Station Subsystem (BSS) is one entity**
  - Made up of BTS, BSC, and transcoder (TC)
- **Base Station Controller (BSC)**
  - Relatively complex (lines-of-code) and low volume compared to BTS
  - From the network vendor perspective this can lead to higher margin and less competition

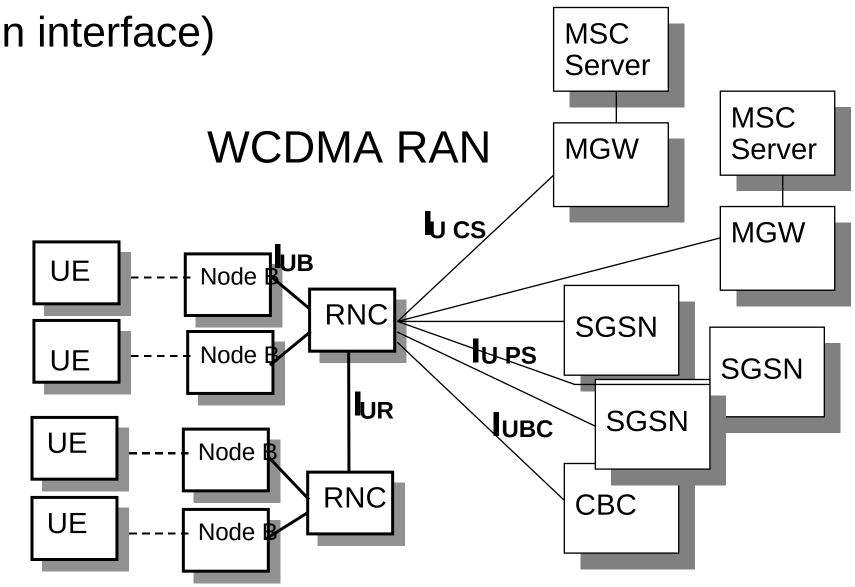
Transcoding in GSM BSS

- **Transcoder does conversion of G.711 PSTN traffic to and from a GSM speech codec and framing**
- **A good example where typical physical implementation differs from logical architecture**
- **It can be located at the core network mobile switch center (MSC) site**
  - Resulting in bandwidth saving in transport network between BSC and MSC

WCDMA Radio Access Network (RAN) Architecture

- **WCDMA Radio Access Network (RAN) was standardized building on GSM**
- **Main function of the WCDMA Radio Network Controller (RNC) is to control and manage the RAN and radio channels**
- **Radio Network Controller is connected to**
  - Node B over I_{ub} (in theory an open interface)
  - Other RNC(s) over I_{ur}
  - Circuit core over I_u-CS
  - Packet core over I_u-PS





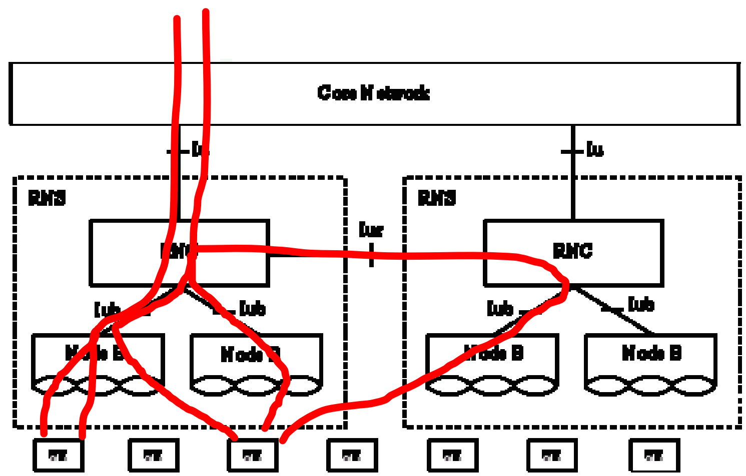
3rd Generation Partnership Project: *Technical Specification Group RAN; UTRAN; Overall Description*; 3G TS 25.401

Radio Network Controller

- **Capacity figure is related to the amount of end users**
- **Connectivity is related to the amount of Node B's and cells that can be connected to it**
- **Order of magnitude figures for a RNC**
  - Hundreds of Node Bs
  - Thousand cells
  - Tens of thousands of active calls
  - Hundreds of thousands users in the geographic area
- **RNC has three separate logical roles**
  - Controlling RNC (CRNC)
    - Each base station (Node B) has exactly one CRNC which is responsible for that base station and all cells belonging to it
  - Serving RNC (SRNC)
    - When an user equipment (UE) is connected to the network, it is always associated with exactly one SRNC
  - Drift RNC (DRNC)
    - DRNC exists in a situation where SRNC has a connection to a UE through a cell that is controlled by another RNC. The other RNC is then CRNC for the cell in question and at the same time DRNC for the UE

Soft Handover (Handoff /US/)

- Softer handover
- Soft handover
- Inter RNC soft handover branch (Drift RNC)

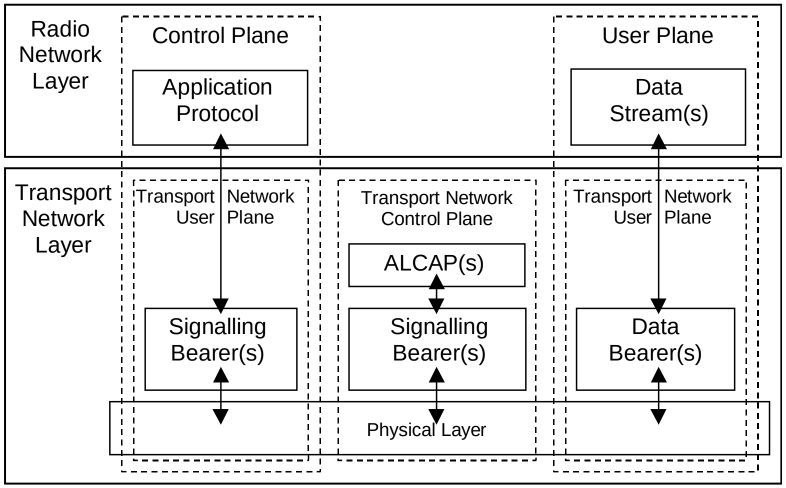


Soft Handover (SHO)

- **Happens when an UE is connected to two or more Node B's simultaneously**
  - If the UE is connected to two cells in the same Node B it is referred to as softer handover
- **Resulting macrodiversity combining (MDC) is the fundamental reason why SRNC user plane is not just a transport switch**
- **Is SHO worth the complexity it brings?**
- **SHO branch setup and teardown performance is critical**
  - Especially circuit switched calls

User and Control Plane

- **RNC functionality can be divided into control plane and user plane.**
- **User plane includes all the functionality that participates directly in the transfer of the user's data payload.**
- **Control plane includes functionality that does not touch the end user's data streams; its functions exist only to enable the correct working of user plane.**
  - Control plane does still transfer data of its own. This data transfer is called *signaling*, and it occurs between network elements, being never directly seen by the end user.
- **The main focus of this presentation is on user plane**



RNC Control Plane 1/2

- **Radio Resource Management**
  - Admission Control
  - Resource Manager
  - Packet Scheduler
  - Load Control
  - Power Control
  - Hand-over control
- **Management of terrestrial channels**
  - Allocation of traffic channels in Iu and Iub interfaces
- **Management of radio channel configurations in RAN**

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RNC Control Plane 2/2

- **Maintenance**
  - Fault localization
  - Reconfiguration of RNC and reconfiguration support for Node B
  - Software updates in RNC and Node B
- **Operation**
  - Modification of parameters of RNC and BTS
  - Modification of the radio access network
  - Configuration of RNC HW
  - Administration of RNC equipment
- ***Very server like tasks***

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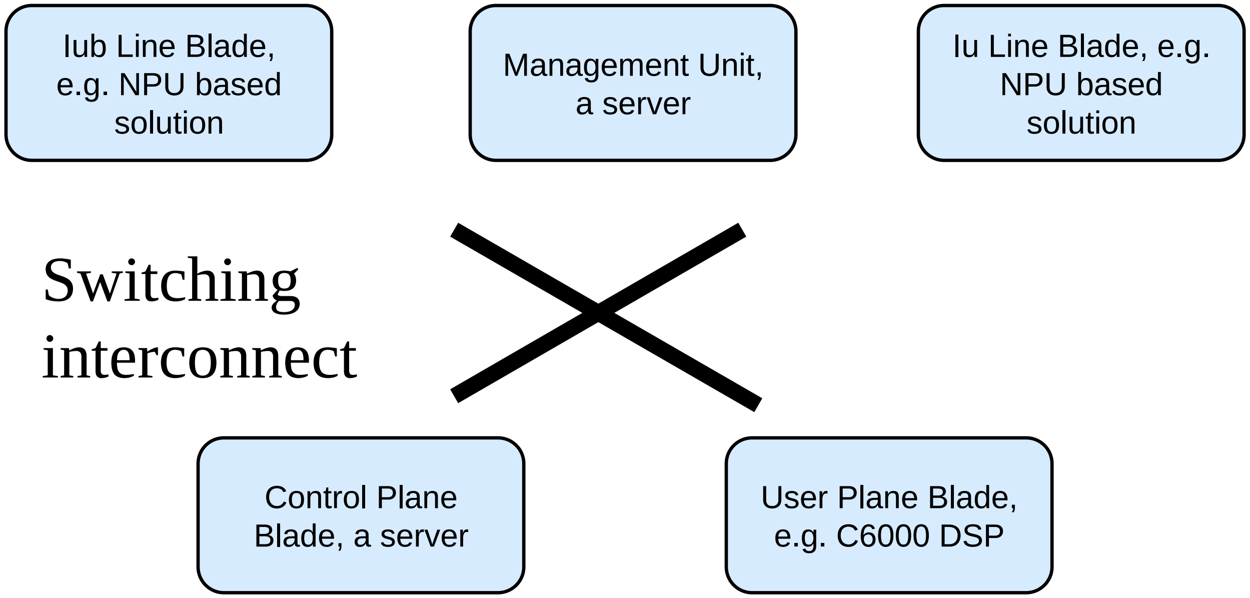
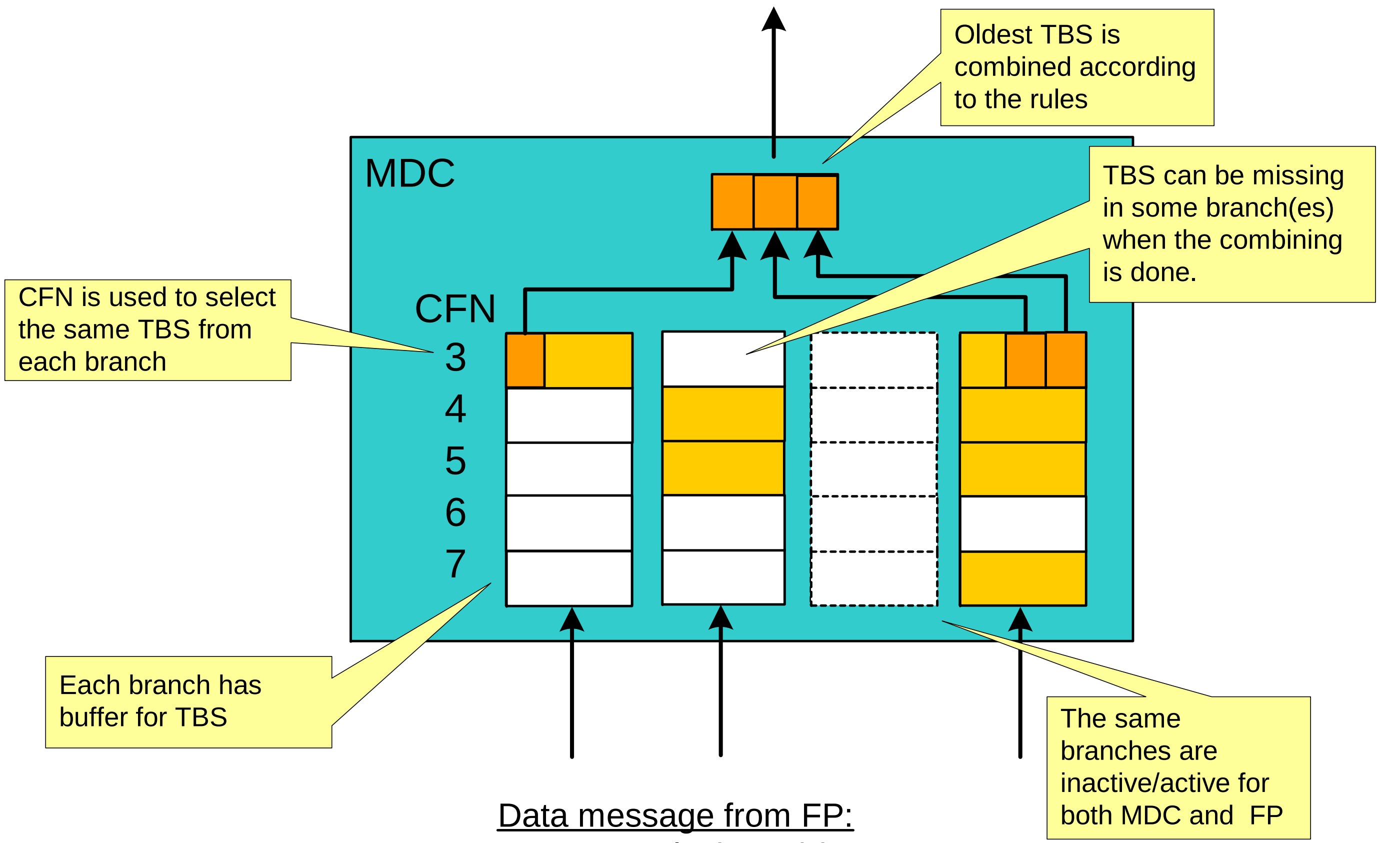
User Plane

- **Frame Protocol (FP) for Iub and Iur**
- **Iu-CS User Plane protocol towards the core network (CN),**
- **Radio Link Control (RLC)**
- **Air Interface ciphering and data integrity verification**
  - f8 and f9 based on the Kasumi algorithm (128bit key)
- **Media Access Control (MAC)**
- **Macrodiversity combining and splitting of the MAC frames**
- **Outer Loop Power Control (OLPC)**
- **Packet Data Converge Protocol (PDCP) including header compression**
- **GPRS Tunneling Protocol (GTP)**
- ***real-time fast path data processing***

Physical Implementation of User Plane and Control Plane



Macrodiversity Combining



<u>Data message from FP:</u>
Transport Block Set(s)
CRC-information
Quality Estimate (QE)

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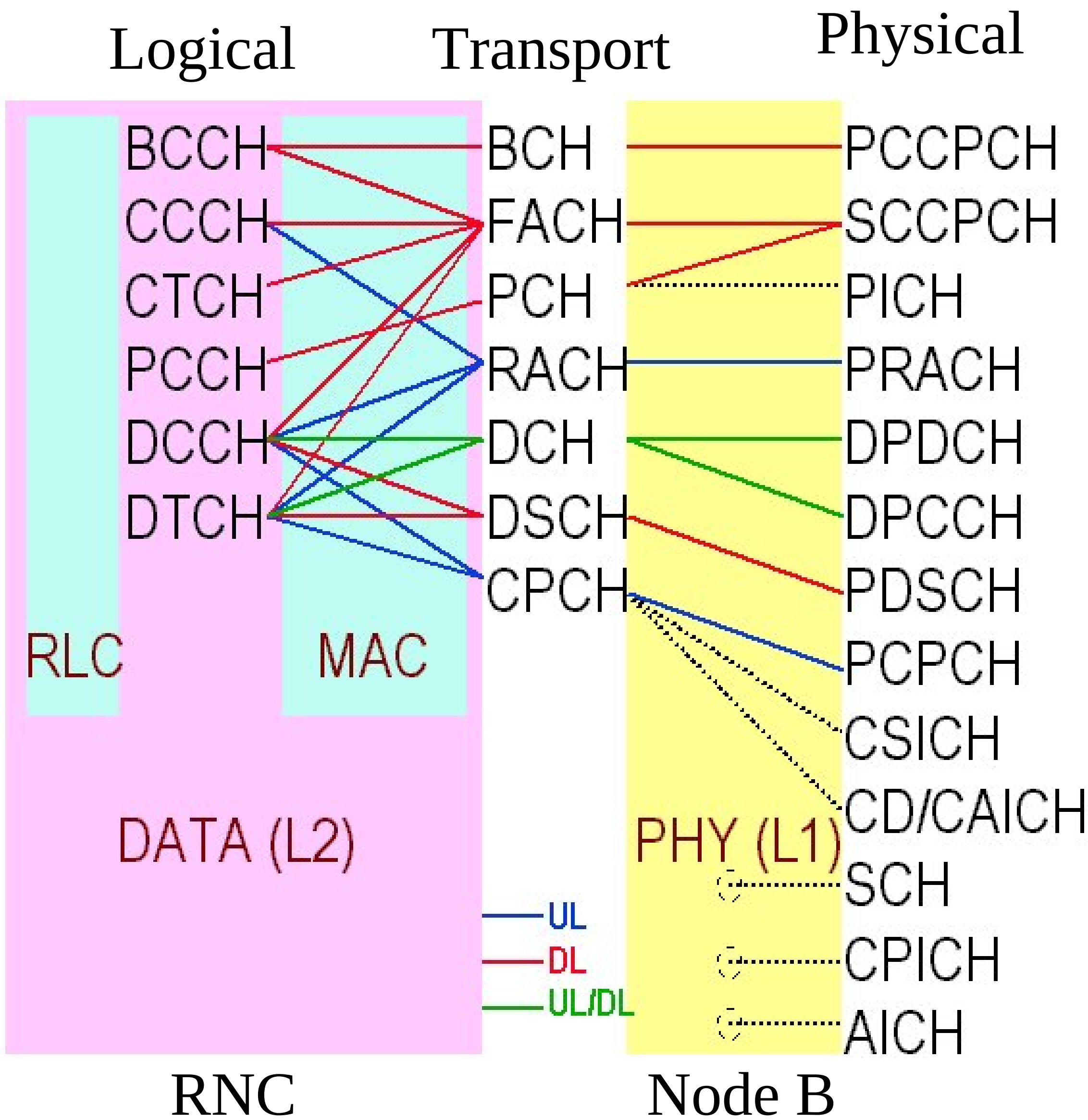
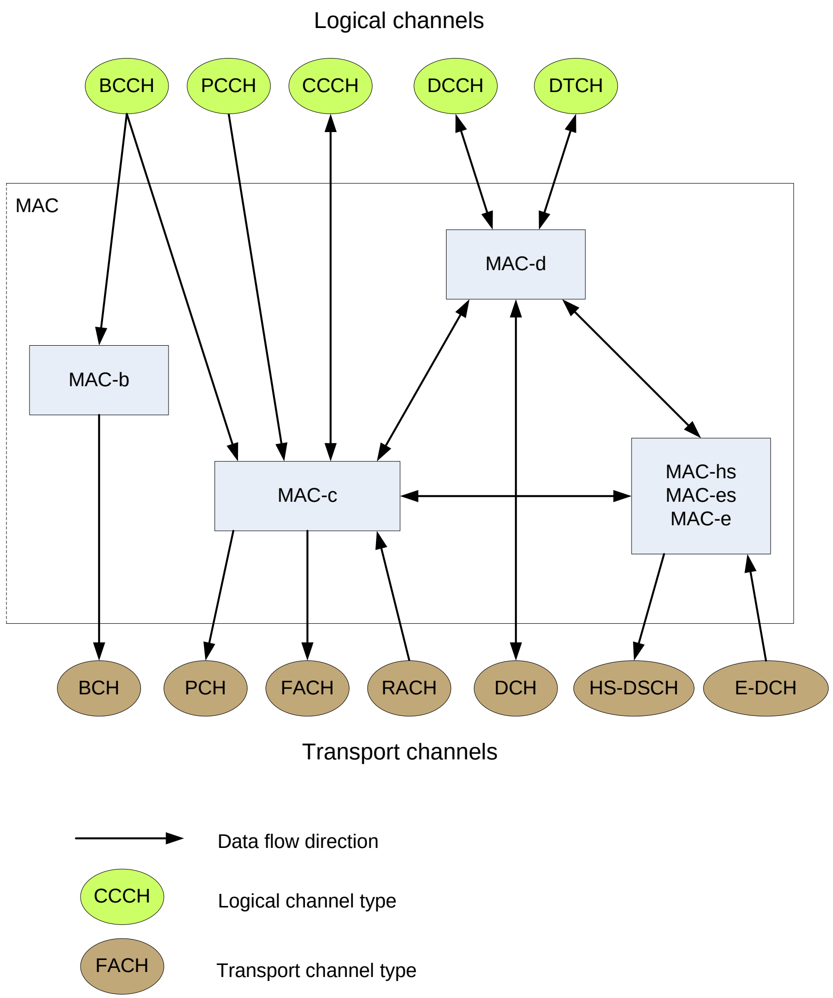
Channels



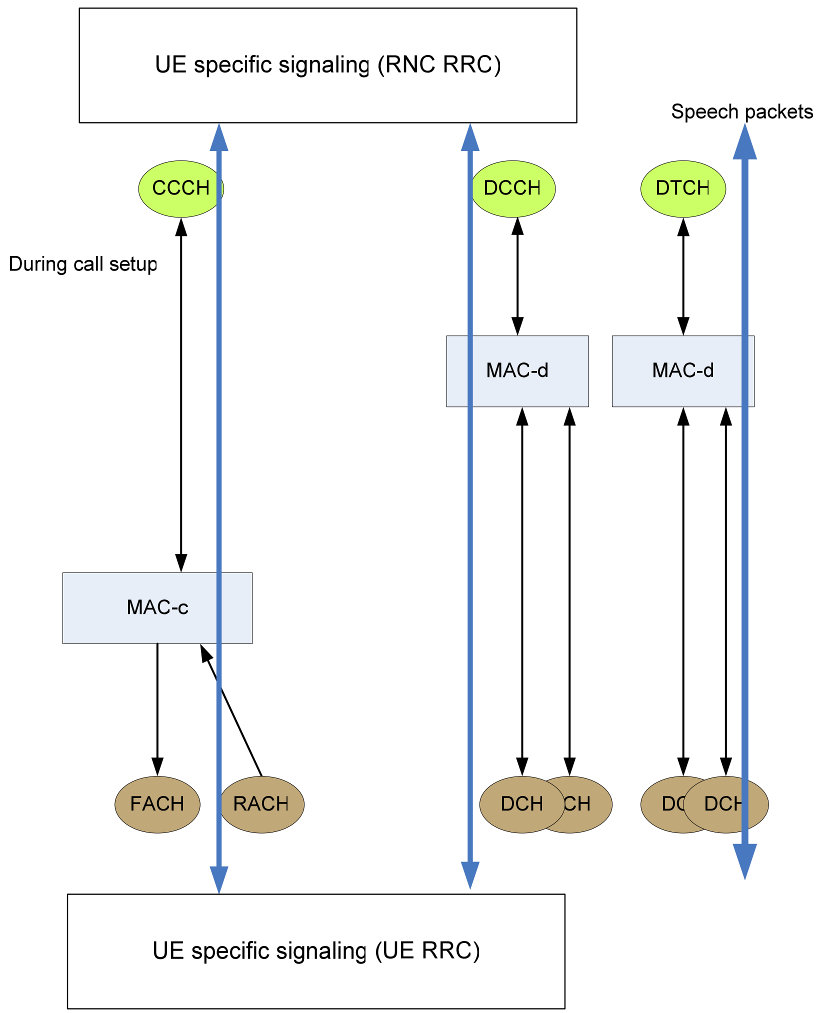
A look at MAC architecture



MAC

- *b – broadcast*
- c – common
- d – dedicated
- *hs – high speed (downlink) shared*
- *es – enhanced (uplink) shared*
- e – enhanced (uplink)

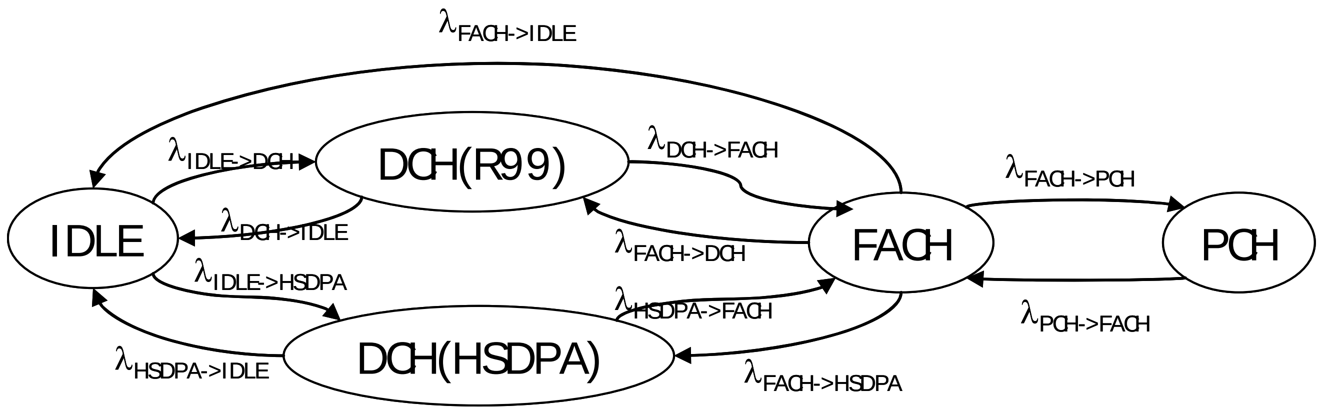
Basic Mobile Originated Speech Call



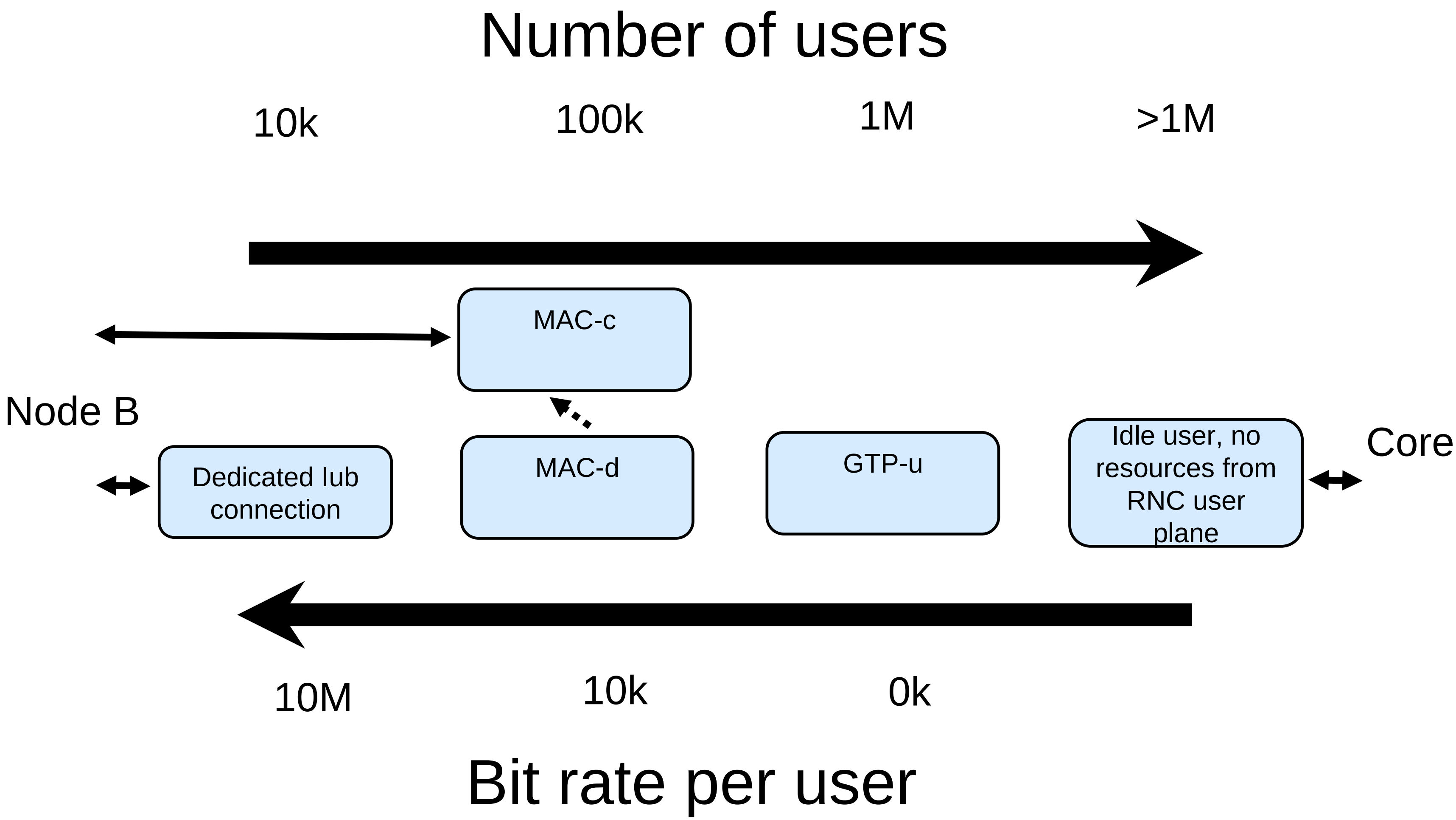
- **CCCH is used during call setup**
- **The UE is connected to two Node Bs**

State Transitions 1/2

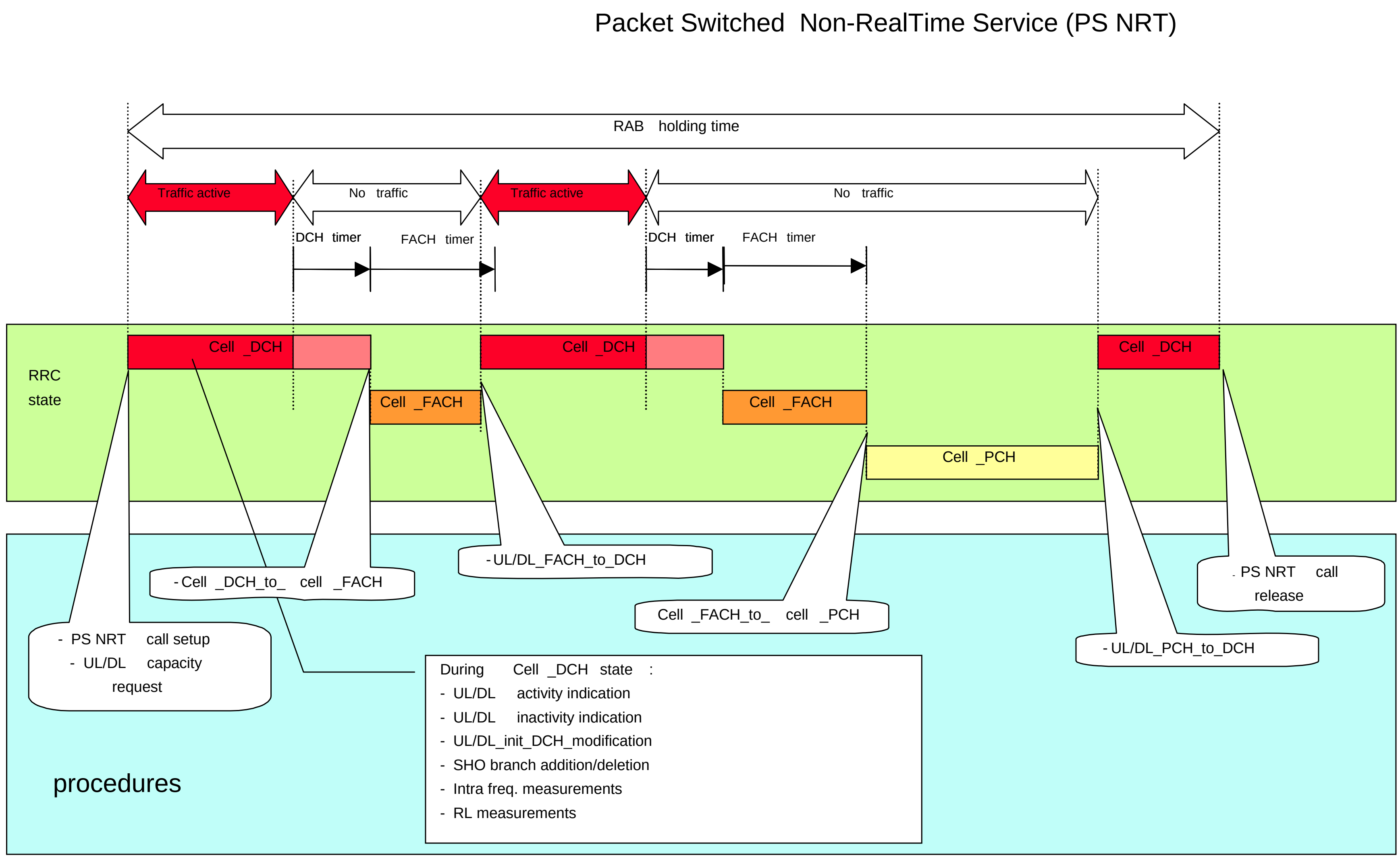
- **The SRNC controls the state of the UE (the phone)**
  - Most relevant in packet data transfer
- **This interaction of user plane and control plane is critical functionality of a RNC**



State Transitions 2/2



State Transition Example



Current Offerings

- **Circuit switched speech**
  - Narrow band adaptive multi-rate codec at 12.2kbit/s mode
- **Packet switched traffic**
  - Typically maximum of 384kbit/s downlink
  - 64kbit/s and 128kbit/s limits also common
- **Video calls**
  - 64kbit/s circuit switched data call with video and speech
- **First generation RNC's have been in use for about 5 years**

Evolution of RNC

- **High speed packet access (HSPA)**
- **First in the downlink HSDPA**
  - HSDSCH channel for RNC
  - Rather easy for RNC user plane (No SHO and more relaxed timing requirements) compared to a DCH of the same bit rate
  - Should become common this year
- **Later in the uplink HSUPA**
  - E-DCH channel for RNC
  - About as complex as a DCH channel of the same bit rate for RNC user plane
- **Bit rates in theory up to 14.4MBit/s in the downlink and 5.76MBit/s in the uplink**
  - First services available are likely to be significantly lower speed because of a number of real world limitations
  - User experience will be at ADSL level (~1.5MBit/s)

Multimedia Broadcast and Multicast Service (MBMS)

- Positioned between DVB-H broadcasting and basic streaming
- MBMS is a part of 3GPP Rel.6, standard froze
- MBMS requires dedicated capacity that could other-wise be used for conventional voice or data services
- 2G and 3G networks can be used for MBMS
- Requires new functionality in the network
- Requires support from terminals
- If this takes off remains to be seen

Centralized Architecture

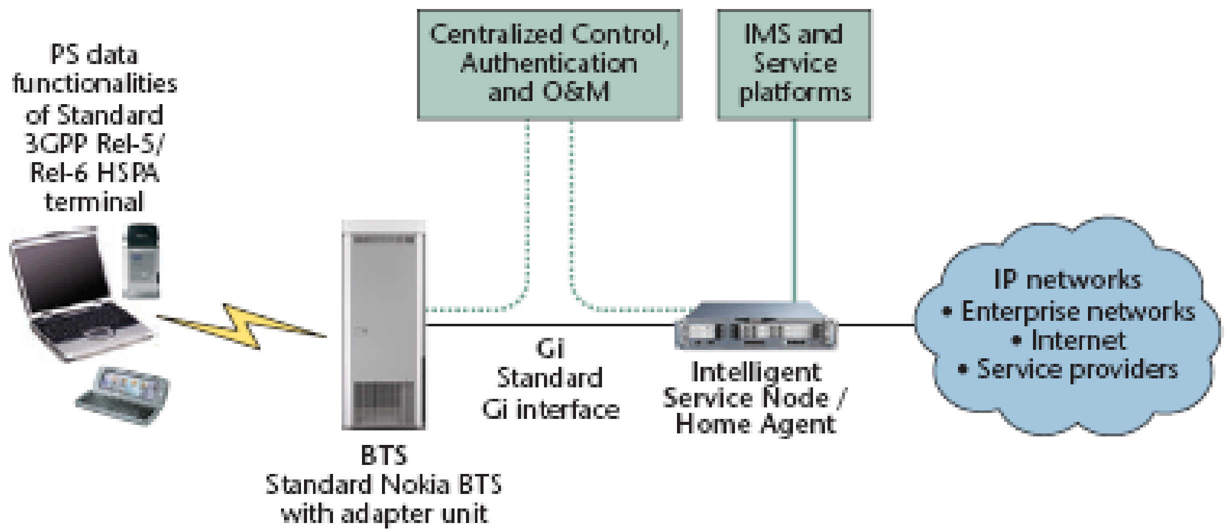
- **Continue on the current path**
- **Fix the problems and optimize**
- **Possible focus areas:**
  - High capacity in general
  - High packet data capacity
  - Scalability to lower smaller configurations
  - New radio technologies
  - Make it cheaper

ATCA

- **A HW standard**
- **ATCA seems like a good fit to a RNC**
- **Interest from operators**
  - Usually operators are not that interested on HW details
- **Intel has built a RNC proof of concept**
  - ATCA based
- **Some publicly announced telecom vendor plans to use ATCA**

Distributed Architecture

- **One alternative for a flat architecture**
- **Move the logical RNC to Node B**
  - Essentially a miniature capacity RNC with a subset of the full functionality in each Node B
- **Or move just the user plane to Node B**
  - A similar approach as splitting MSC to Server and Gateway in 3GPP release 4 core network



HSPA with flat architecture, Nokia Internet-HSPA

Benefits of Flat Architecture

- 3GPP standards based simplified network architecture
- Solution for cost-efficient broadband wireless access
- Utilizes standard 3GPP terminals

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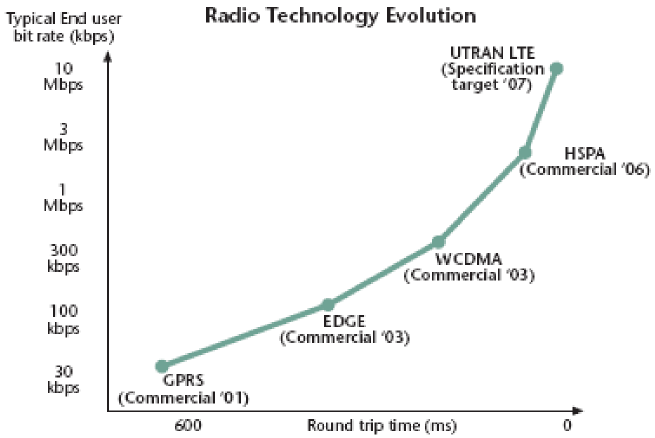
Some Influencing Factors

- **Transport network evolution**
  - Currently a typical Node B is connected with one or few E1/T1 lines (for a total capacity of several MBit/s)
  - IP (and Ethernet) is coming, some issues remain
- **Telecom is an installed base game**
  - Once equipment is sourced changes are usually slow
- **RNC is just a minor part of RAN**
  - Node B is the major part
- **New radio technologies are coming**



High Capacity RNC

- **How large capacity a single RNC could be?**
  - In some markets operators want as big as possible
- **High Availability (HA) requirements**
  - What if one RNC serves 10 million users and 100 000 simultaneous speech calls
  - HA costs
- **How to compromise between packet data and circuit voice capacity**

Scaled Down RNC

- **How small capacity RNC still makes sense?**
- **Something like a single ATCA chassis**
  - Roughly current (with HSPA) capacity and smaller and cheaper
  - This could fit into operators site solutions and overall network
- **Something smaller like uTCA**
  - Or proprietary mechanics

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