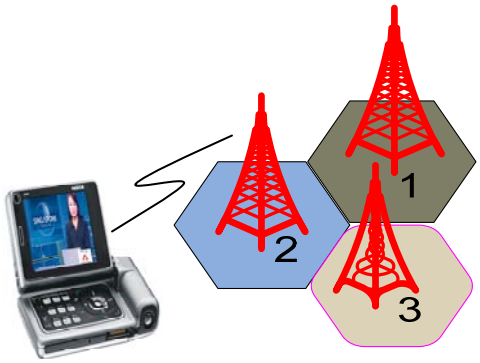
Lappeenranta University of Technology

Department of Information technology

Assignment of “Network Design and Traffic Engineering”



UMTS

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Abbreviations

UMTS	Universal Mobile Telecommunication Systems
WCDMA	Wideband Code Division Multiple Access
3GPP	3rd Generation Partnership Project
TDD	Time Division Duplexing
FDD	Frequency Division Duplexing
TD-CDMA	Time Division-CDMA
GSM	Global System of Mobile Communication
GPRS	General Packet Radio Service
CN	Core Network
UTRAN	UMTS Terrestrial Radio Access Network
UE	User Equipment
ME	Mobile Equipment
MSC	Mobile Switching Center
VLR	Visitor Location Register
GMSC	Gateway MSC
SGSN	Serving GPRS Support Node
GGSN	Gateway GPRS Support Node
MGW	Media Gateway
EIR	Equipment Identity Register
HLR	Home Location Register
AUC	Authentication Center
RNC	Radio Network Controller
PSTN	Public Switched Telephone Network
ISDN	Integrated Services Digital Network
BSC	Base Stations Controller
BTS	Base Transceiver Station
QoS	Quality of Service
SIM	Subscriber Identity Module
USIM	UMTS Subscriber Identity Module
IMSI	International Mobile Subscriber Identity
IMEI	International Mobile Equipment Identity
TMSI	Temporary Mobile Subscriber Identity
P-TMSI	Packet Temporary Mobile Subscriber Identity
MSISDN	Mobile Station ISDN
TLLI	Temporary Logical Link Identity
IP	Internet Protocol
SMS-PP	Short Messages Service-Point to Point
SMS-CB	Short Messages Service-Cell Broadcast
ARQ	Automatic Repeat Request
FIFO	First In First Out
ATM PVC	Asynchronous Transfer Mode Permanent Virtual Connections

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UMTS

1 INTRODUCTION

UMTS stands for Universal Mobile Telecommunication System. It is 3rd Generation standard cellular mobile technology. It is also known as WCDMA technology. It was standardized by the 3GPP. UMTS has wide bandwidth of 5 MHz spectrums as carrier channel. In this WCDMA technology, the user signal is multiplied with pseudo random noise signal before transmitting. Each user has own unique code. The same frequency channel is allocated to each user. It means many users can use the same channel at the same time. In UTMS networks, the modulation scheme is known as Wideband Code Division Multiple Access (WCDMA), which has two basic modes of operation: TDD mode (using TD-CDMA) or FDD (using W-CDMA). Due to wide spectrum, it supports a wide range of services including voice, data, paging, Fax, messaging, Internet, video and so on with global mobility. The maximum data speed of UMTS is 2 Mbps. UMTS supports both types of data switching domains: circuit switched and packet switched domains so that it can be compatible to GSM and GPRS services respectively.

2 NETWORK ARCHITECTURE/ ELEMENTS

A UMTS network consists of three main sections:

1. Core Network (CN)
2. UMTS Terrestrial Radio Access Network (UTRAN)
3. User Equipment (UE)

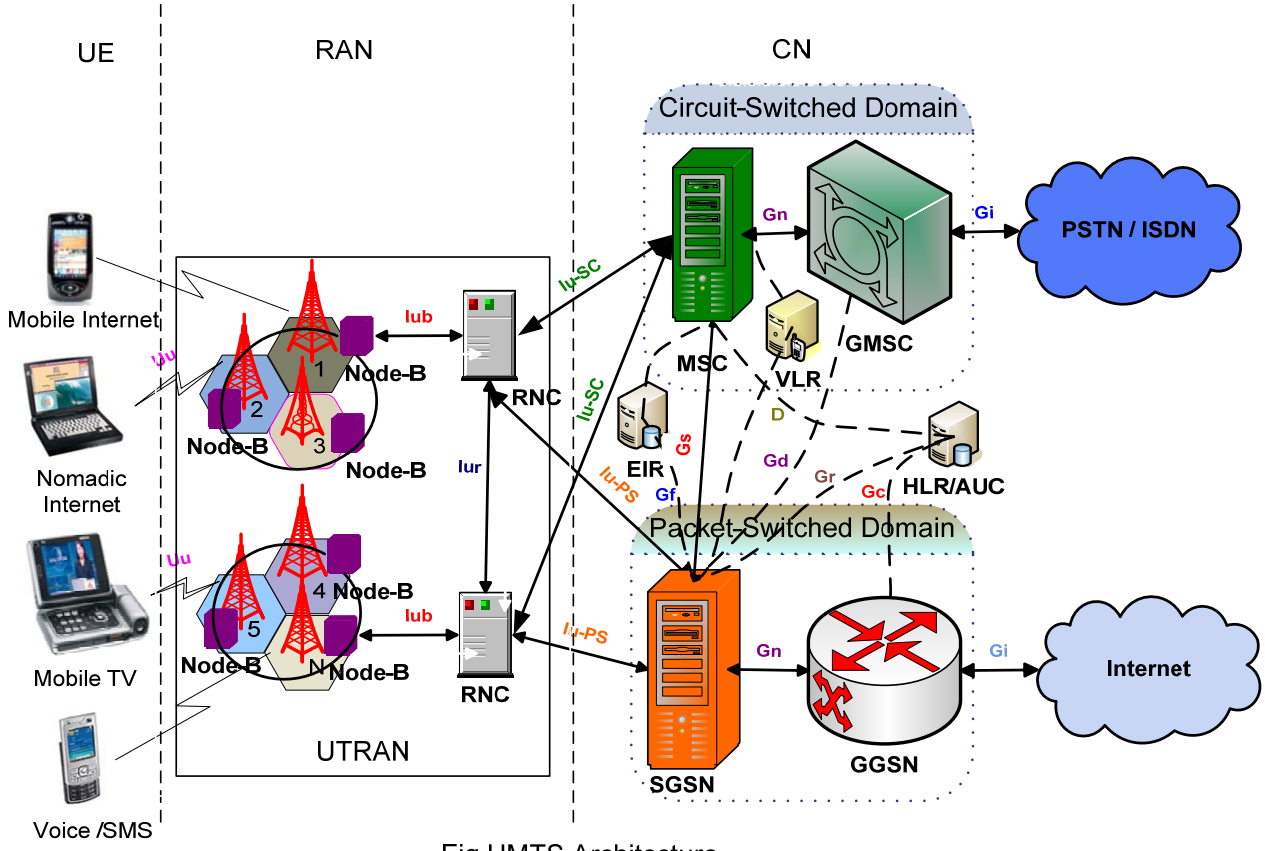

Fig.UMTS Architecture

2.1 Core Network (CN)

The basic CN architecture is based on GSM network with GPRS. The Core Network is divided into two domains: circuit switched and packet switched domains.

The circuit switched domain elements are:

1. Mobile Switching Center (MSC)
2. Visitor Location Register (VLR)
3. Gateway MSC (GMSC)

Whereas the packet switched domain elements are:

4. Serving GPRS Support Node (SGSN)
5. Gateway GPRS Support Node (GGSN)

Besides these elements, some elements like, EIR, HLR, VLR and AUC are the shared elements of both domains.

The main function of the CN is to provide switching, routing and transit for user traffic.

2.1.1 Mobile Switching Center (MSC)

The main task of MSC is to route, switch and transmit the circuit switched data received from Radio Network Controller (RNC) to the PSTN / ISDN networks via GMSC. MSC is the core element of GSM network. In GSM network, the billing operation was done by MSC but in UMTS there is a separate element, which manages billing.

2.1.2 Visitor Location Register (VLR)

VLR is a network database that keeps information about the roaming mobile customers.

2.1.3 Gateway MSC (GMSC)

GMSC is the main routing element for the circuit switched data from the UMTS to the PSTN or ISDN network or vice-versa. A GMSC is the MSC that determines which visited MSC the subscriber who is being called currently located. All mobile-to-mobile calls and PSTN to Mobile calls are routed through GMSC.

2.1.4 Serving GPRS Support Node (SGSN)

The main task of SGSN is to route, switch and transmit the packet switched data received from Radio Network Controller (RNC) to the Gateway GPRS Support Node or vice-versa via the interface Gn.

2.1.5 Gateway GPRS Support Node (GGSN)

Like GMSC is the main routing element for circuit switched data to the PSTN or ISDN network, GGSN is the main routing element for the packet switched data of UMTS network to the Ethernet network.

Equipment Identity Register (EIR)

The EIR is a database that keeps a list of mobile phones (identified by their IMEI), which are to be banned from the network or monitored.

Home Location Register (HLR)

The HLR is a central database that contains details of each mobile phone subscriber that is authorized to use the GSM network. More precisely, the HLR stores the details of every SIM card issued by the mobile phone operator.

Authentication Center (AUC)

The function of AUC is to authenticate each SIM card that attempts to connect the GSM network. Once the authentication is successful, the HLR is allowed to manage the SIM and services.

2.2 UMTS Terrestrial Radio Access Network (UTRAN)

UTRAN is the sensitive section of the mobile network. The main changes are occurring in this section for the evolution of new technology. UTRAN consists of two elements:

1. Radio Network Controller (RNC)
2. Node B

2.2.1 Radio Network Controller (RNC)

The RNC is the governing element in the UMTS radio access network (UTRAN) responsible for control of the Node-Bs, that is to say the base stations that are connected to the controller. One RNC can control multiple Node-Bs. The RNC in UMTS networks functions equivalent to the Base Stations Controller (BSC) functions in GSM/GPRS networks. The RNC is carried out radio resource management; some of the mobility management functions and is the point where encryption is done before user data is sent to and from the mobile. The RNC connects to the Circuit Switched Core Network through MSC (which is also known as Media Gateway, MGW) and Packet Switched Core Network through SGSN.
The main function of the RNC is management of radio channels (Uu-, or Air-, interface) and terrestrial channels (towards the MGW and SGSN). Resource management functionality includes:

- Radio Resource Control
- Admission Control
- Channel Allocation
- Power Control Settings
- Handover Control
- Load Control
- Macro Diversity
- Broadcast Signaling
- Packet Scheduling
- Security Functions
- Open Loop Power Control
- Mobility Management

2.2.2 Node-B

The Node-B is that element in the UMTS network, which provides the physical radio link between the User Equipment (UE) and the network. The Node-Bs in UMTS networks provides functions equivalent to the Base Transceiver Station (BTS) in GSM/GPRS networks. Node-B is typically physically co-located with existing GSM BTS to reduce the cost of UMTS implementation.
The Node-B is responsible for air interface processing and some Radio Resource Management functions. The functions of Node-B are:

- Air Interface Transmission / Reception
- Modulation/ Demodulation
- CDMA Physical Channel Coding
- Micro Diversity
- Error Handling

- Closed Loop Power Control

2.3 User Equipment (UE)

The UMTS UE is based on the same principles as the GSM MS- the separation between mobile equipment (ME) and the UMTS subscriber identity module (SIM) card (USIM). The UMTS standard does not restrict the functionality of the UE in any way. Terminals work as an air interface counter part for Node-B and have many different types of identities. Most of these UMTS identities types are taken directly from GSM specifications:

- International Mobile Subscriber Identity (IMSI)
- Temporary Mobile Subscriber Identity (TMSI)
- Packet Temporary Mobile Subscriber Identity (P-TMSI)
- Mobile Station ISDN (MSISDN)
- Temporary Logical Link Identity (TLLI)
- International Mobile Station Equipment Identity (IMEI)

3 NETWORK SERVICES/ TRAFFIC

The UMTS services are divided into four main classes:

1. Bearer Services
2. Teleservices
3. Supplementary Services
4. Service Capabilities

3.1 Bearer Services

Bearer services provide the capability for information transfer between access points and only lower layer functions. Bearer services are characterized by a set of end-to-end characteristics with requirements on QoS. The service characteristics includes like traffic type, supported bit rates and the quality of information. The following are the brief description of the bearer services:

- Information Transfer
- Information Quality
- Supported Bit Rates

- **Information Transfer:**

Both connections oriented and connectionless services are supported by UMTS services.

Traffic Type:

The bearer service provides one of the following:

- Guaranteed/ constant bit rate
- Non-guaranteed/ dynamically variable bit rate, and
- Real time dynamically variable bit rate with a minimum guaranteed bit rate

Real time and non real time application are as follows:

- *Real time video, audio and speech*
  This means the services should have ability to provide a real time stream of guaranteed bit rate, end to end delay and delay variation, ability to provide a real time conversational service of guaranteed bit rate, end to end delay and delay variation.
- *Non real time interactive and file transfer services*
  This means ability to support message transport with differentiation as regards QoS between different users.
- *Multimedia applications*
  This implies there should be ability to support several users' flows to and from on user having different traffic types (e.g., real time, non real time).

Traffic Characteristics:

The traffic characteristics may be

A. Point-to-point
   - Uni-Directional

- Bi-Directional
- Symmetric
- Asymmetric

B. Uni-Directional Point-to-Multipoint
   - Multicast
   - Broadcast

- **Information Quality:**

The information quality characterizes the bit integrity and delay requirements of the applications.

Maximum Transfer Delay:

Transfer delay is the time between the requests to transfer the information at one access point to its delivery at the other access point.

Delay Variation:

The delay variation of the information received over the bearer has to be controlled to support real-time services.

Data Rate:

The data rate is the amount of data transferred between the two access points in a given period of time.

- **Supported Bit Rates:**

The offered data rates of UMTS are:

- 144 kbits/s in satellite and rural outdoor radio environment
- 384 kbits/s in urban/ suburban outdoor radio environment
- 2 Mbits/s in indoor and low range outdoor radio environment

3.2 Teleservices

Teleservices provide the full capabilities for communications by means of terminal equipment, network elements, and possibly elements provided by dedicated centers. Teleservices contain both single media and multimedia services. Some of the teleservices are:

- Speech/ Telephony
- Emergency Calls
- SMS-Point to Point (SMS-PP)
- SMS-Cell Broadcast (SMS-CB)
- Internet Access

Teleservices utilizes the bearer services provided by lower layers. The Bearer Services and the Teleservices are not coupled to each other so as to aid independent development and changes to one may not necessarily mean changes to other.

3.3 Supplementary Services

A supplementary service modifies or supplements a basic telecommunication service. Consequently, it can not be offered to a user as a stand alone service. A stand alone service can be either Bearer Service o Teleservice but can not be Supplementary service.

The following are some of the supplementary services:

- Call Forward
- Call Deflection
- Call Waiting
- Call Hold
- Call Restriction and Call baring
- Number Identification

3.4 Service Capabilities

Service Capability features are open, technology independent building blocks accessible via a standard application interface. This interface shall be applicable for a number of different business and applications domains.
Two different types of service capability features can be distinguished for detail:

- *Framework service capability features:* these shall provide commonly used utilities, necessary for the non-framework service capability features to be accessible, secure, resilient and manageable.
- *Non-Framework service capability features:* these shall enable the applications to make use of the functionality of the underlying network capabilities (e.g., User Location service capability features).

Examples of Framework Service Capability features are

- Authentication
- User-Network Authentication
- User-Application Authentication
- Authorization
- Application-Network Authorization
- User-Application Authorization
- Registration
- Discovery
- Notification

Examples of Non-Framework Service Capability features are:

- Session Control
- Security/ Privacy

- Address Translation
- Location
- User Status
- Terminal Capabilities
- Messaging
- Data Download
- User Profile Management
- Charging

In overall, UMTS network services have different QoS classes for four types of traffic:

- Conversational class (voice, video telephone, video gaming)
- Streaming class (multimedia, video on demand, webcast)
- Interactive class (web browsing, network gaming, database access)
- Background class (email, SMS, download)

4 UMTS INTERFACES

The following are the new UMTS interfaces compared to GSM/GPRS networks:

- Iu-CS
  - This is the circuit-switched connection for carrying voice traffic and signaling between the UTRAN and the core network.
  - This is the equivalent interface in GSM/GPRS network in the A-interface.
- Iu-PS
  - Packet-switched connection for carrying data traffic and signaling between UTRAN and the core data GPRS network.
  - Equivalent interface in GSM/GPRS networks in Gb interface.
- lur
  - The primary purpose of lur is to support inter-MSC mobility. When a mobile subscriber moves between areas served by different RNCs, the mobile subscriber's data is now transferred to the new RNC via lur. The original RNC is known as the Serving RNC and the new RNC is known as the Drift RNC.
  - No equivalent interface in GSM/GPRS networks.
- lub
  - The interface between RNC and multiple Node-Bs to control the Node-Bs.
  - Equivalent interface in GSM/GPRS networks is the Abis interface.
- Uu
  - The interface between the User Equipment and the Node-B. That is, it is the UMTS air interface.
  - Equivalent interface in GSM/GPRS networks is the Um interface.

5 TRAFFIC MODEL

The model reflects the delay statistics on the IP layer including the correlation properties. In order to derive the model, we consider the arbitrary sequence of IP packets. Each of these IP packets is first stored in the radio network's input buffer. The UMTS data link reads the packets from the buffer at the effective line speed. Subsequently, a read packet is delayed by the line speed transmission time as well as by additional processing and propagation delay. Finally the IP packets experience the delay at the receiver.
This behavior can directly be mapped to the queuing model as shown in fig below. A traffic generator generates IP packets, which are first stored in a bounded FIFO queue. Subsequently, a single server delays the IP packets according t the effective line speed of the radio link. That is, the service time is deterministic and depends on the packet length. The subsequent infinite server accounts for processing and propagation delays and for the delay introduced by the core network and the Internet. The final infinite server accounts for the reordering delay introduced by the Automatic Repeat Request (ARQ) mechanism. The service time of this infinite server follows a general distribution.

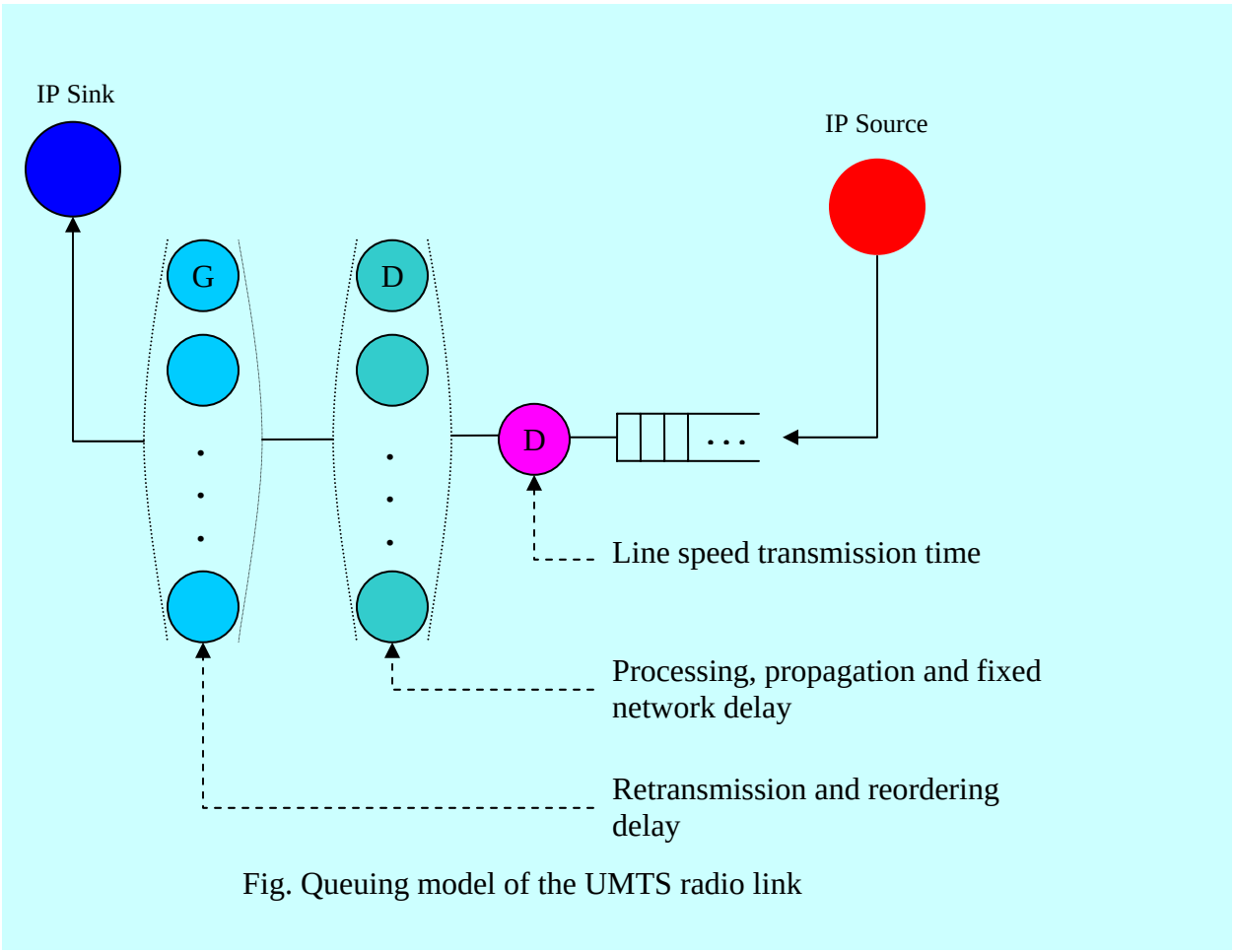

Fig. Queuing model of the UMTS radio link

6 NETWORK TOPOLOGY

UMTS is playing an important role at present and also going to play in future telecommunications. Thus, the transport network of UMTS (UTRAN) is going to be a rather complex and high-capacity system. These large and costly systems are going to be deployed in very short timeframes, which emphasizes the importance of a good network design methodology. In fact, the complexity of the system, the high cost factors and the shorter design timeframes call network topology optimization methods.

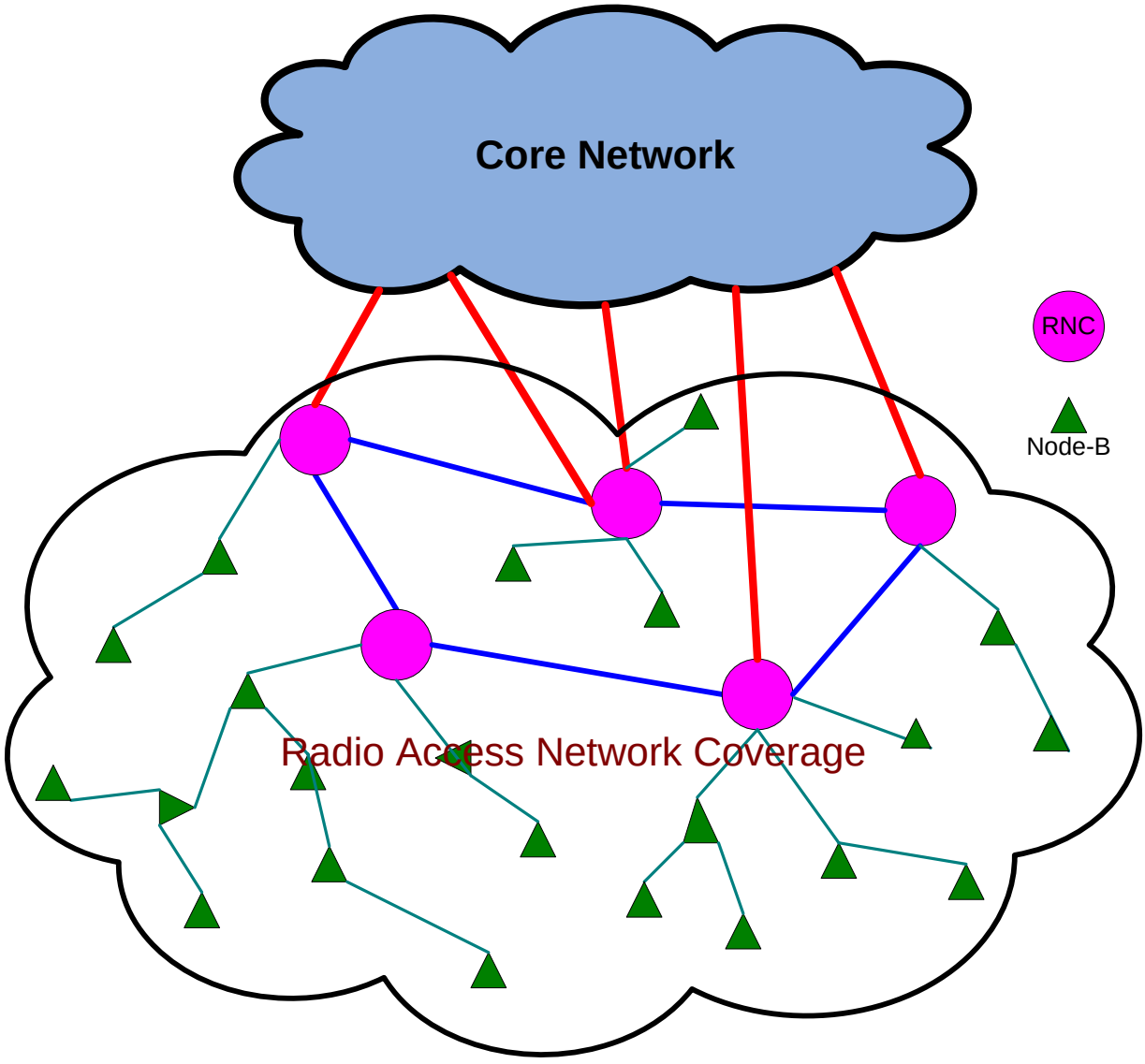

Fig. Network Topology

One of the simple methods we can use first, we find the cost-optimal number and location of Base Station Controller nodes in the network. Second, we find a cost-optimal interconnection network connecting Base Transceiver Stations (Node-Bs) to the BSC. On logical level, each BTS (Node-

B) is connected directly to its home BSC using ATM PVCs (Permanent Virtual Connections), so the logical topology of the UMTS network is a set of star subnetworks. On physical level, the BTSs are connected to their home BSC directly as well or through some other BTSs using leased line or microwave interconnections. It means that the physical level network topology is a set of trees.

Due to various technological reasons there is a constraint on how many BTSs can be connected to a BSC, on logical level further on this limit will be called BSC degree. On physical level the maximum number of BTS's connected parallel to an upper level BTS is limited; in this case we say that there is a degree constraint for each BTS. Also there is a constraint on the depth of the BTS subtrees, which means how many other BTSs can be placed between a BSC and a BTS on physical level,in other words, how many BTSs can be cascaded in the network. This constraint is called cascading constraint.

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