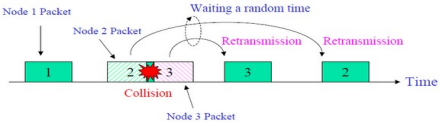
【Multiple Radio Access】

1. 每個節點都與傳送/接收端相連，透過共享的媒介互相通訊
2. Multiple access issues
   超過一個結點傳送資料所發生的碰撞
3. Multiple access protocols
   (1) Contention protocols
   碰撞發生後如何解決
   (2) Collision-free protocols
   確保碰撞永遠不發生
4. Medium sharing techniques
   (1) 靜態頻道化
   (2) 動態媒體存取控制(DMAC)

Contention Protocols

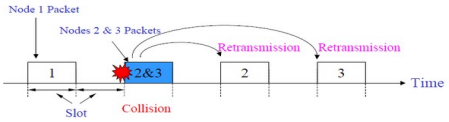
ALOHA: S = G exp(-2G)

- Whenever a station has a data, it transmits.
- Sender finds out whether transmission was successful or experienced a collision by listening to the broadcast from the destination station.
- Sender retransmits after some random time if there is a collision.



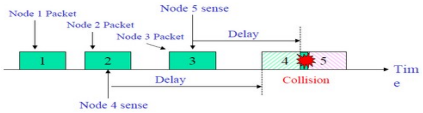
Slotted ALOHA: S = G exp(-G)

- Time is slotted and a packet can only be transmitted at the beginning of one slot.



CSMA (Carrier Sense Multiple Access)

- 若無其他傳送進行，則進行傳送。



CSMA (Carrier Sense Multiple Access)

1. Non-persistent CSMA:
   Step 1: medium is idle→transmit.
   Step 2: medium is busy→wait a random amount of time and repeat **Step 1.**
   - Random backoff reduces probability of collisions.
   - Waste idle time if the backoff time is too long.
2. 1-persistent CSMA Protocol:
   Step 1: medium is idle→transmit.
   Step 2: medium is busy→continue to listen until medium becomes idle, and then transmit.
   - There always have a collision if two nodes want to retransmit.
3. p-persistent CSMA Protocol:
   Step 1: If the medium is idle, transmit with probability p, and delay for one propagation delay with probability (1-p).
   Step 2: If the medium is busy, continue to listen until medium becomes idle, then go to **Step 1.**
   Step 3: If transmission is delayed by one time slot, continue with **Step 1.**

How to Select Probability *p* ?

Assume that *N* nodes have a packet to send and the medium is busy

1. *Np* is the expected number of nodes that will attempt to transmit once the medium becomes idle
2. If *Np* > 1, then a collision is expected to occur.

Therefore, network must make sure that *Np* < 1, where *N* is the maximum number of nodes that can be active at a time.

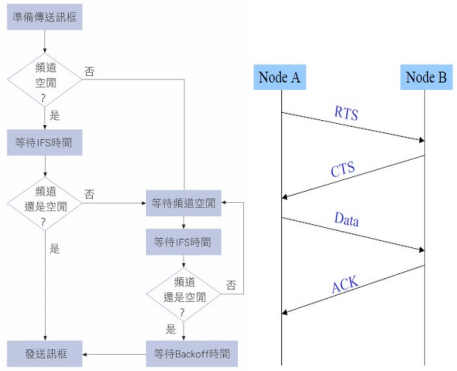
CSMA/CD (Collision Detection)

1. Each will transmit its complete packet.
2. Wasting medium for an entire packet time.
3. 若傳送時偵測到碰撞，則停止傳送。

Step 1: If the medium is idle, transmit.
Step 2: If the medium is busy, continue to listen until
the channel is idle then transmit.
Step 3: If a collision is detected during transmission,
cease transmitting.
Step 4: Wait a random amount of time and repeats the same algorithm.

CSMA/CA (Collision Avoidance)

傳送前先偵測，若無進其他傳送，則進行傳送。



CSMA/CA with ACK

1. Immediate Acknowledgements from receiver upon reception of data frame.
2. ACK frame transmitted after time interval SIFS (*Short Inter-Frame Space*) (*SIFS* < *DIFS*)
3. Receiver transmits ACK without sensing the medium.
4. If ACK is lost, retransmission done.

CSMA/CA with RTS/CTS

1. Transmitter sends an RTS (request to send) after medium has been idle for time interval more than DIFS.
2. Receiver responds with CTS (clear to send) after medium has been idle for SIFS.
3. Data is exchanged.
4. RTS/CTS is used for reserving channel for data transmission so that the collision can only occur

【GSM & GPRS】

基地台子系統（BSS）

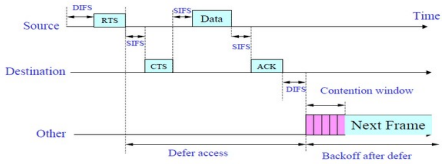
- MS（Mobil Station）移動台／移動用戶
- BS（Base Station）基地台
- BSC（Base Station Controller）基地台控制器
- BTS（base Transceiver Station）基地收發

GSM 所提供的服務

1. 通話服務
2. 多人通訊服務
3. 無線封包服務
4. 短訊息服務

GSM 硬體架構圖

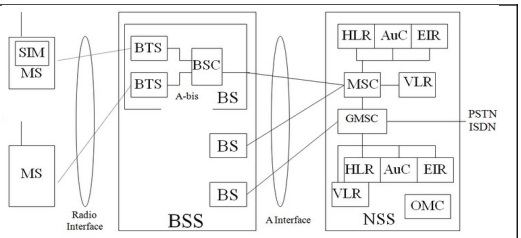
in control message.



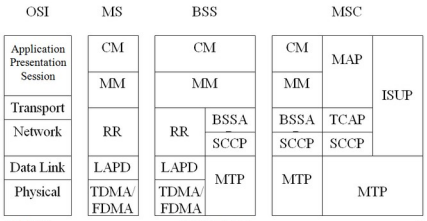
信台

網路子系統（NSS）

- MSC (Mobile Switch Center) 移動交換中心
- VLR (Visitor Location Register) 拜訪位置暫存器
- HLR (Home Location Register) 所屬位置暫存器
- AC (Authentication Center) 權限中心
- EIR (Equipment Identity Register) 設備識別暫存器
- OMC (Operation & Maintenance Center) 操作維護中心



GSM 通訊協定架構

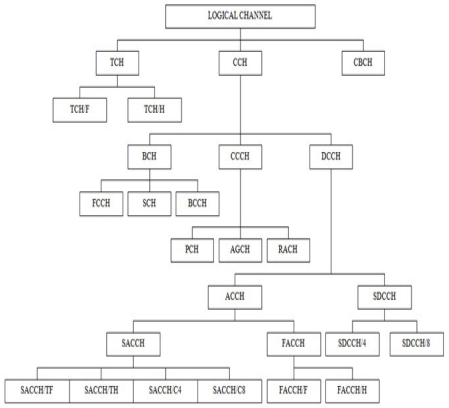


1. 實際通訊頻道 (Physical Channel)

- 時槽（Time Slot）為傳送單位，每個時槽扣除末端 8.25 bit 的 Guard Time 稱為一個 Burst。
- 8 個 Time Slots 可以合成一個 Frame，26 個 Frames 可以合成一個 Multiframe，26 個 Multiframes 可以合成一個 Super Frame，51 個 Super Frames 可以合成一個 Hyper Frame，最多有 2048 個連續的 Hyper Frames。

2. 邏輯通訊頻道 (Logical Channel)

每個邏輯頻道都相對應一個實體頻道，也就是位於某個特定載波頻率的某個特定時槽，無線傳輸的各種功能就是透過這些邏輯頻道完成。



1. 服務頻道 (TCH)
   傳送用戶的語音或數據資料。
2. 信號頻道 (CCH)
   載送網路與手機間所需的控制信號相關訊息。
   (1) 廣播頻道 (BCH)
   基地台透過廣播頻道傳送相同的訊息，給在此細胞涵蓋範圍中的所有手機（含待機及通話中）。
   - 頻率校正頻道 FCCH：用來校正載波頻率。
   - 同步頻道 SCH：調整訊框同步。
   - 廣播控制頻道 BCCH：傳送網路一般訊息。

   (2) 共用控制頻道 (CCCH)
   與正在進行通話的特定手機間傳遞訊息。
   - 隨機存取頻道（RACH）
   在 GSM 網路中，每個用戶在進行通話前，必須先向網路取得一個空的時槽才能開始通訊，隨機存取頻道讓手機送出頻道使用申請給基地台。
   - 存取允許頻道（AGCH）
   至於手機所提出申請是否成功，則由基地台正確接收到手機送出頻道使用申請後，透過存取允許頻道，將頻道使用權的確認回應送回手機。
   - 呼叫頻道（PCH）
   當有外來電話要打給某個手機之前，讓基地台用來呼叫手機。

   (3) 專用控制頻道（DCCH）
   在基地台與特定手機之間傳送控制訊息。
   - 獨立專屬控制頻道（SDCCH）
   通話尚未進行前，讓手機與基地台之間傳送建立通訊鏈結所需要的相關信號。
   - 慢速聯合控制頻道（SACCH）

Summary

- GSM represents a first approach to personal communication at anytime, anywhere, to anyone.
- Differentiation and Generality of GSM network architecture forms a basis for next generation of mobile communication technology.

【GPRS】

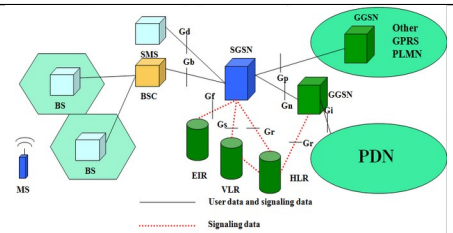
GSM Data Limitations

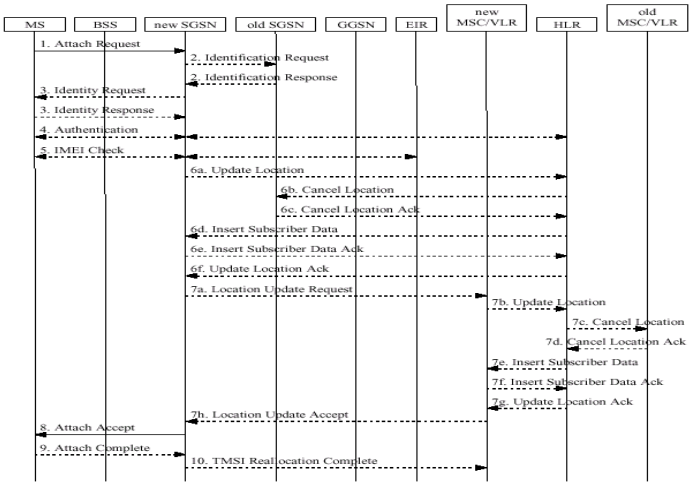
- Uplink and downlink channels allocated for a user entire call period

GPRS Objectives

1. GPRS uses packet switched resource allocation.
2. Dynamic channel allocation
   - Available resources shared by active users.
   - Up and down link channels reserved separately.
   - GPRS and circuit switched (GSM) services can use same time slots alternatively.
3. Efficient delivery of SMS over the GPRS air interface
4. Connections with data networks.

GPRS Applications

通話中，持續提供手機與基地台之間所必須的信號訊息。 - 快速聯合控制頻道（FACCH） 緊急時(手機需更換服務基地台)，及時提供手機與基地台之間所必須的信號訊息。 （SACCH 和 FACCH 都是在通話中，在手機與基地台之間傳送控制訊息的通道。）	- Low bandwidth per user (9.6 Kbps). - User pays based on duration, not based on volume. - GSM is designed for speech, not data.	1. Standard data network protocol based 2. GPRS specific protocol based
GPRS Characteristics 1. Transmission modes - Send and receive data in packet. - Cost effective and efficient use of network resources. 2. Traffic characteristics - Transient bursty data transmissions. - Frequent transmission of small amount of data. 3. Transmission Four level of radio priorities and five classes of QOS supported PTP and PTM. **GSM v.s. GPRS** 1. GSM - Connections with circuit switched networks. - Continuous flow of data in both direction. - Every MT call causes query to HLR. - All services activated at IMSI attach. - Charging is based on time.	2. GPRS - Connection with external packet data networks. - Typical connection can last several hours. - Data transmission bursty. - Uplink and downlink transmissions independent - Packets are small. - Every network element knows where to rout packet further. - No need to access HLR for every GPRS packet - User can activate each service separately. - Charging is based on amount of transmitted data. - **Bearer services and supplementary services** - Point-to-point service (PTP) - Point-to-multipoint service (PTM) - SMS service - Anonymous service	**GPRS Quality of Service** - Service precedence The priority of a service in relation to another service - Reliability Indicates the transmission characteristics required by an application - Delay Parameters Defines maximum values for the mean delay and the 95-percentile delay - Throughput Specifies the maximum/peak bit rate and mean bit rate **Detachment procedure** - IMSI detach, GPRS detach, IMSI/GPRS combine detach. - MS-Initiated detach, Network-Initiated detach.
 **【Bluetooth】** **What is Bluetooth?** 1. A short-range wireless technology. 2. Desired for several needs: (1) Interconnecting a computer and peripherals. →Clear the snake's nest behind the desk. (2) Interconnecting various handheld devices. →Preplanning of network is impractical. (3) Any short-range application low cost is essential. →量產才能降低成本。 (4) Intended to be embedded in other devices. 3. Bluetooth is not another wireless LAN.	**What does Bluetooth do for me?** 1. Data Access Point. 2. Cable Replacement. 3. Personal Ad-hoc Connectivity. →藍芽並非萬能，只能在短距離內使用。 **Remember Infra-Red** 紅外線不能做到的事情，藍芽來做。 1. A short-range wireless technology. 2. Low-cost, reasonable data rate. 3. Pushed by Hewlett-Packard (HP). 4. Most laptops adopted it. 5. Lots of cellphones and palmtops have it. 6. No software of general connectivity. 7. Moral: HP printer don't have IR ports.	**Bluetooth Characteristics** - Operates in the 2.4 GHz band at a data rate of 720Kbps. - Uses Frequency Hopping (FH) spread spectrum, which divides the frequency band into a number of channels (2.402~2.480 GHz yielding 79 channels). - Radio transceivers hop from one channel to another in a pseudorandom fashion, determined by the master. - Supports up to 8 devices in a piconet (1 master and 7 slaves). Piconets can combine to form scatternets. **The Bluetooth network topology** 1. Radio Designation (1) Connected radios can be master or slave. (2) Radios are symmetric (same radio can be master or slave). 2. Piconet (1) Master can connect to 7 simultaneous or 200+ inactive (packed) slaves per piconet. (2) Each piconet has maximum capacity (1 MSps). (3) Unique hopping pattern/ ID. 3. Scatternet: Piconet can coexist in time and space.



- GPRS backbones
  - Intra-PLMN
  - Inter-PLMN