

Wireless Communication

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Key Reference:

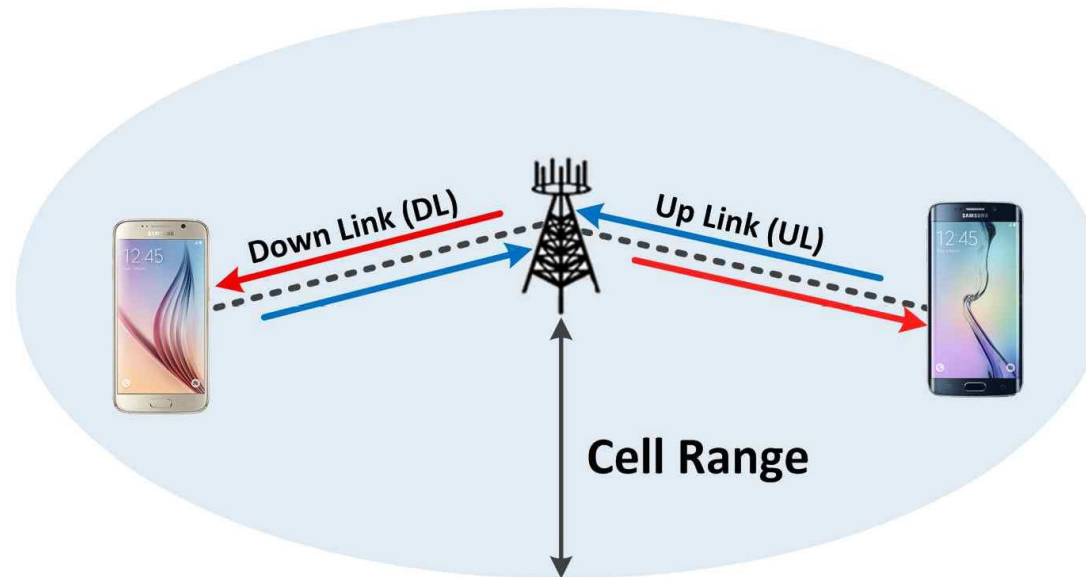
Prof. Jong-Moon Chung's Lecture Notes at Yonsei University

Wireless Communications

- Bluetooth
- Wi-Fi
- Mobile Communications
- LTE
- LTE-Advanced

Mobile Communications Handover

- ▶ Downlink & Uplink



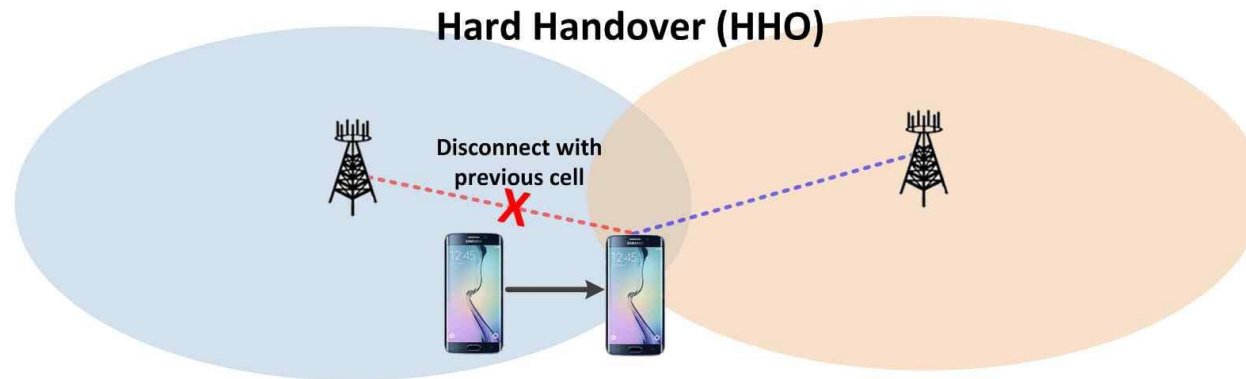
Mobile Communications Handover

▶ Handover



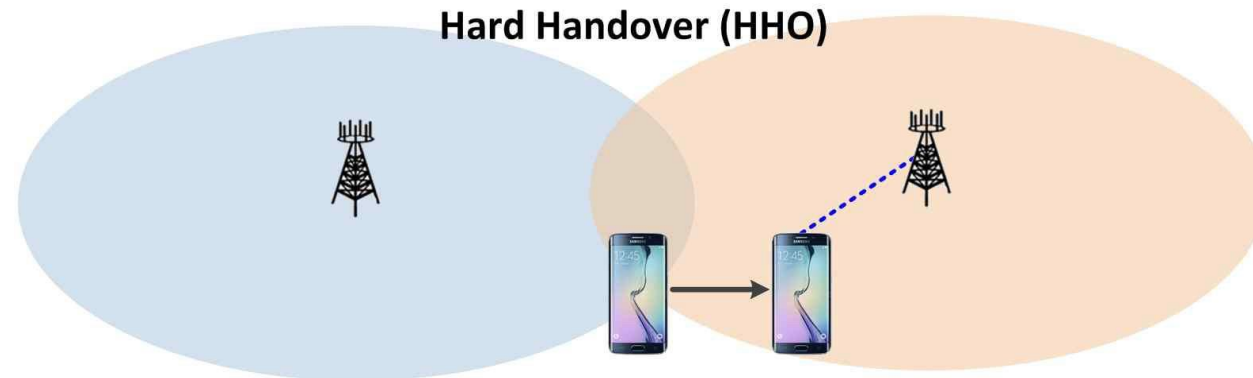
Mobile Communications Handover

▶ Handover



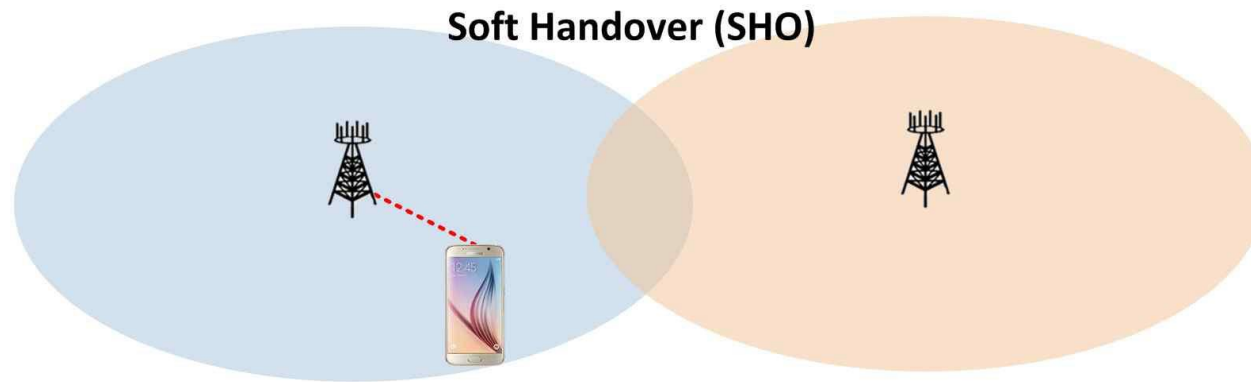
Mobile Communications Handover

▶ Handover



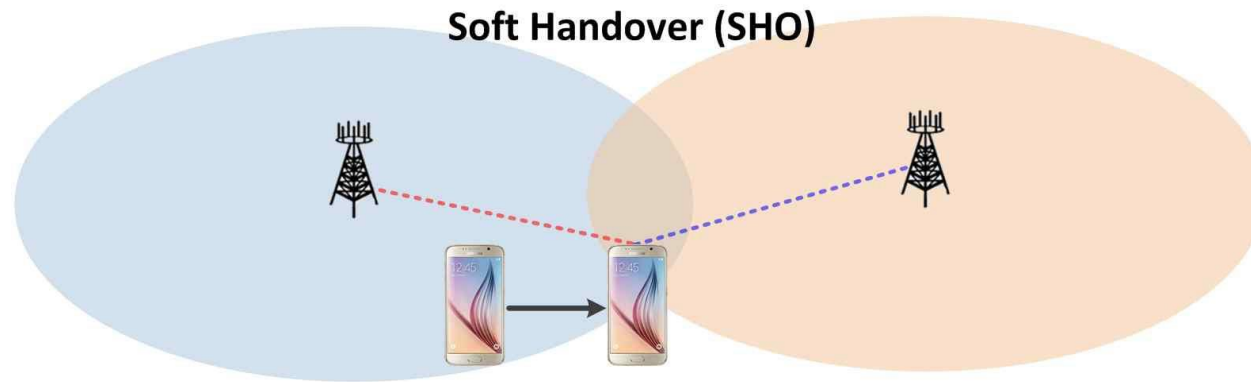
Mobile Communications Handover

▶ Handover



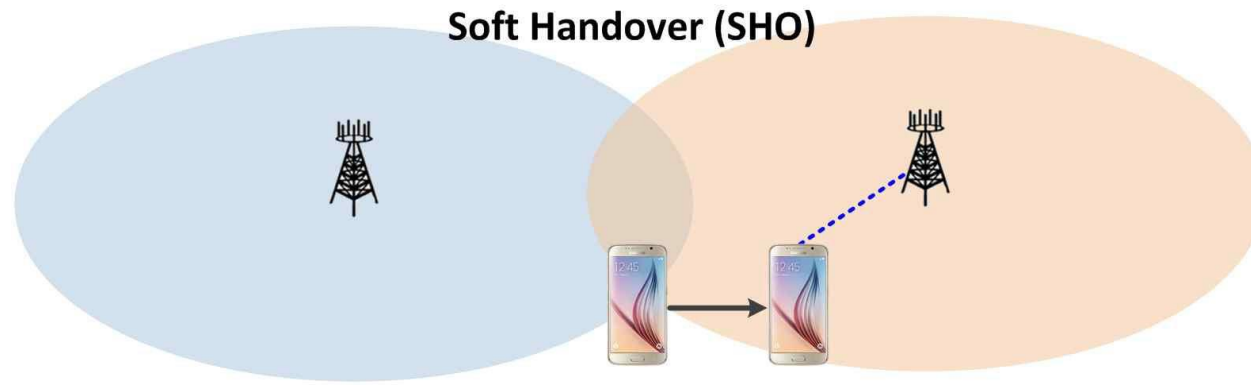
Mobile Communications Handover

▶ Handover



Mobile Communications Handover

► Handover



Basic Mobile Communications Structure

- **Structure of the mobile phone cellular network**
 - A network of radio **base stations** forming the **base station subsystem**.
 - The **core circuit switched network** for handling voice calls and text
 - A **packet switched network** for handling mobile data
 - The **public switched telephone network (PSTN)** to connect subscribers to the wider telephony network

Mobile Communications



- ▶ **Mobile Phone Evolution**
 - **1st Generation (1G)**
 - **AMPS**
 - **2nd Generation (2G)**
 - **GSM, IS-95 (cdmaOne)**
 - **3rd Generation (3G)**
 - **UMTS (WCDMA), CDMA2000**
 - **4th Generation (4G)**
 - **LTE-A**

List of Mobile Phone Generations

V·T·E		Cellular network standards	[hide]
List of mobile phone generations			
0G (radio telephones)	MTS · MTA - MTB - MTC - MTD · IMTS · AMTS · OLT · Autoradiopuhelin · B-Netz		
1G	AMPS family	AMPS (TIA/EIA/IS-3, ANSI/TIA/EIA-553) · N-AMPS (TIA/EIA/IS-91) · TACS · ETACS	
	Other	NMT · C-450 · Hicap · Mobitex · DataTAC	
2G	G SM/3GPP family	GSM · CSD · HSCSD	
	3GPP2 family	cdmaOne (TIA/EIA/IS-95 and ANSI-J-STD 008)	
	AMPS family	D-AMPS (IS-54 and IS-136)	
	Other	CDPD · iDEN · PDC · PHS	
2G transitional (2.5G, 2.75G)	G SM/3GPP family	GPRS · EDGE/EGPRS (UWC-136)	
	3GPP2 family	CDMA2000 1X (TIA/EIA/IS-2000) · CDMA2000 1X Advanced	
	Other	WiDEN	
3G (IMT-2000)	3GPP family	UMTS (UTRA-FDD / W-CDMA · UTRA-TDD LCR / TD-SCDMA · UTRA-TDD HCR / TD-CDMA)	
	3GPP2 family	CDMA2000 1xEV-DO Release 0 (TIA/IS-856)	
3G transitional (3.5G, 3.75G, 3.9G)	3GPP family	HSPA (HSDPA · HSUPA) · HSPA+ · LTE (E-UTRA)	
	3GPP2 family	CDMA2000 1xEV-DO Revision A (TIA/EIA/IS-856-A) · EV-DO Revision B (TIA/EIA/IS-856-B) · EV-DO Revision C	
	IEEE family	Mobile WiMAX (IEEE 802.16e) · Flash-OFDM · iBurst (IEEE 802.20)	
4G (IMT Advanced)	3GPP family	LTE Advanced (E-UTRA) · LTE Advanced pro (4.5G pro) · LTE Advanced(pre 5G) (4.9G)	
	IEEE family	WiMAX (IEEE 802.16m)	
Proposed	5G		
Related articles	Cellular networks · Mobile telephony · History · List of standards · Comparison of standards · Channel access methods · Spectral efficiency comparison table · Cellular frequencies · GSM frequency bands · UMTS frequency bands · Mobile broadband · NGMN Alliance · MIMO		

AMPS



- ▶ **Advanced Mobile Phone System (AMPS)**
 - **1st Generation (1G)** mobile cellular phone
 - **Analog** standard using **FDMA** (Frequency Division Multiple Access)
 - Developed by **Bell Labs**
 - Introduced in North America in Oct. **1983**

GSM

- ▶ **Global System for Mobile Communications (GSM)**
 - **2nd Generation (2G)** mobile cellular phone: **Digital** system
 - Introduced in Finland in **1991**
 - Dominant global standard
 - Over **90% market share**
 - Operated in over **219** countries & territories



GSM

- ▶ **Global System for Mobile Communications (GSM)**
 - GSM uses TDMA & FDMA combined
 - **TDMA** (Time Division Multiple Access)
 - **FDMA** (Frequency Division Multiple Access)



GSM

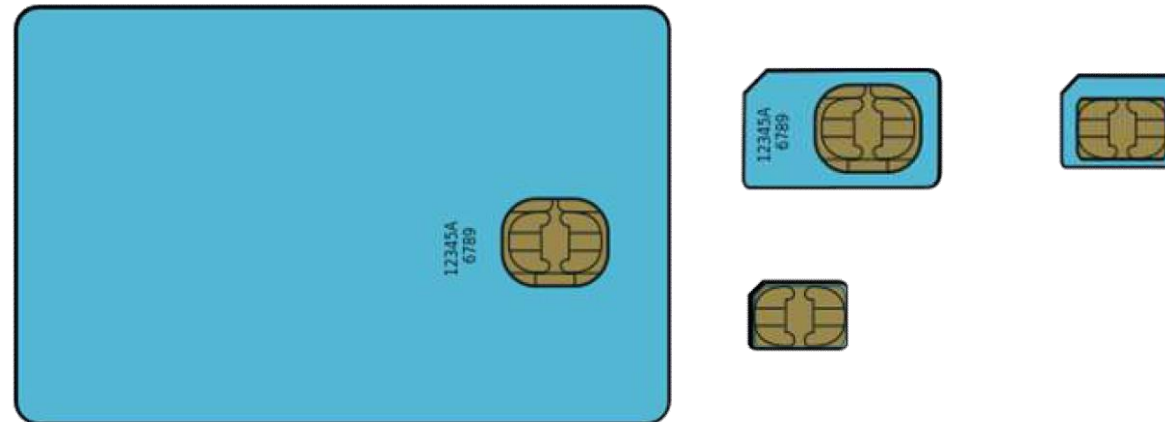
- ▶ **Global System for Mobile Communication (GSM)**
 - GSM supports voice calls and **data** transfer speeds up to **9.6 kbps**, and **SMS** (Short Message Service)



GSM



- ▶ **SIM (Subscriber Identity Module)**
 - SIM is a **detachable smart card**
 - SIM contains user subscription information and phone book



GSM



▶ SIM Advantages

- SIM enables a user to maintain user information even after switching cellular phones
- Or, by changing ones SIM a user can **change cellular phone operators** while using the same the mobile phone

IS-95: cdmaOne



- ▶ **IS-95**
 - **IS-95** (Interim Standard 95) is the first **CDMA** based **2G** digital cellular standard
 - Why CDMA?
CDMA performs well against (narrow band) **interference** and (multipath) signal **fading**
 - **cdmaOne** is the brand name for IS-95 that was developed by Qualcomm



IS-95: cdmaOne



- ▶ **IS-95**
 - Hutchison launched the first commercial cdmaOne network in **Hong Kong** in September **1995**
 - IS-95 traffic channels support **voice** or **data** at bit rates of up to **14.4 kbps**

UMTS



- ▶ **Universal Mobile Telecommunications System (UMTS)**
 - **3rd Generation** (3G) mobile cellular system
 - Evolution of **GSM**
 - **UTRA** (UMTS Terrestrial Radio Access) supports **several different** terrestrial air interfaces



UMTS



- ▶ **Universal Mobile Telecommunications System (UMTS)**
 - **Multiuser Access** in UTRA can be supported by **UTRA-FDD** or **UTRA-TDD**
 - FDD (Frequency Division Duplex)
 - TDD (Time Division Duplex)



UMTS: WCDMA



- ▶ **WCDMA** (Wideband Code Division Multiple Access)
 - **3rd Generation** (3G) mobile cellular system that uses the **UTRA-FDD** mode
 - **3GPP** (3rd Generation Partnership Project) **Release 99**
 - Up to **2 Mbps** data rate



UMTS: WCDMA



► WCDMA

- First commercial network opened in **Japan** is **2001**
- **Seamless** mobility for voice and packet data applications
- **QoS** (Quality of Service) **differentiation** for high efficiency of service delivery
- Simultaneous **voice** and **data** support
- **Interworks** with existing **GSM** networks

CDMA2000

- ▶ **CDMA2000**
 - **3G** mobile cellular system
 - Standardized by **3GPP2**
 - Evolution of **IS-95 cdmaOne** standards
 - Uses CDMA & TDMA
 - CDMA (Code Division Multiple Access)
 - TDMA (Time Division Multiple Access)



CDMA2000

➤ CDMA2000

- Initially used in **North America** and **South Korea** (Republic of Korea)



CDMA2000



▶ CDMA2000 1xEV-DO

- CDMA2000 1xEV-DO (**Evolution-Data Optimized**) enables **2.4 Mbps** data rate
- CDMA2000 1xEV-DO network launched in **South Korea** on January **2002**



CDMA2000



- ▶ **CDMA2000 1xEV-DO**
 - Regarded as the **first 3G system** based on **ITU standards**
 - ITU (International Telecommunication Union) is the specialized agency for information and communication technology of the UN (United Nations)



HSDPA



- ▶ **High-Speed Downlink Packet Access (HSDPA)**
 - **Enhanced 3G** mobile communications protocol
 - **Evolution of UMTS** for higher data speeds and capacity
 - Belongs to the **HSPA** (High-Speed Packet Access) family of protocols



HSDPA



- **High-Speed Downlink Packet Access (HSDPA)**
 - HSDPA commercial networks became available in **2005**
 - **Peak Data Rate**
 - Downlink: **14 Mbps** (Release 5)



EV-DO Rev. A



- **EV-DO Rev. A (Revision A)**
 - **Peak Data Rate**
 - Downlink: **3.1 Mbps**
 - Uplink: **1.8 Mbps**
 - Launched in the **USA** on October **2006**
 - **VoIP** support based on low latency and low bit rate communications



EV-DO Rev. A



- ▶ **EV-DO Rev. A**
 - **Enhanced Access Channel MAC**
 - Decreased connection establishment time
 - **Multi-User Packet** technology enables the ability for more than one user to share the same timeslot
 - **QoS** (Quality of Service) flags included for QoS control



HSPA+

- ▶ **Evolved High-Speed Packet Access (HSPA+)**
 - HSPA+ all IP network first launched in **Hong Kong** in **2009**
 - **WCDMA (UMTS) based 3G** enhancement
 - HSPA+ is a HSPA evolution



HSPA+

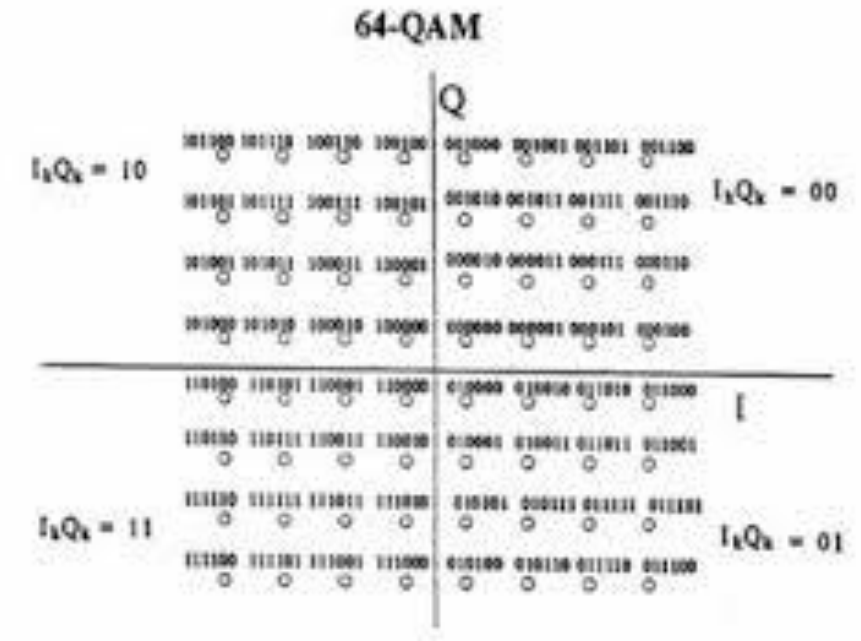


- **Evolved High-Speed Packet Access (HSPA+)**
 - **Peak Data Rate**
 - Downlink: **168 Mbps**
 - Uplink: **22 Mbps**
 - **MIMO** (Multiple-Input & Multiple-Output) multiple-antenna technique applied
 - **Why MIMO?** MIMO uses uncorrelated multiple antennas both at the transmitter and receiver to **increase the data rate** while using the **same signal bandwidth** as a single antenna system.

HSPA+

▶ Evolved High-Speed Packet Access (HSPA+)

- Higher Data Rate Accomplished by
 - **MIMO** multiple-antenna technique
 - Higher order modulation (**64QAM**)
 - **Dual-Cell HSDPA** is used to combine
 - **multiple cells** into one



EV-DO Rev B

- **EV-DO Rev. B (Revision B)**
 - EV-DO Rev. B was first deployed in **Indonesia** on January **2010**
 - **Multi-Carrier** evolution of Rev. A
 - Higher data rates per carrier
 - Downlink Peak
 - **4.9 Mbps** per carrier
 - Uplink Peak
 - **1.8 Mbps** per carrier



EV-DO Rev B



- ▶ **EV-DO Rev. B**
 - **Reduced latency** from **statistical multiplexing** across channels
→ Reduced delay → Improved QoS
 - Longer **talk-time** & **standby time**
 - Hybrid frequency re-use & Reduced interference at Cell Edges and Adjacent Sectors → Improved QoS at the Cell Edge

EV-DO Rev B



- ▶ **EV-DO Rev. B**
 - More Efficient **Asymmetric** Data Rate Support
 - Downlink \neq Uplink Data Rates
 - Asymmetric Service Examples
 - File transfer
 - Web browsing
 - Multimedia content delivery
 - etc.

EV-DO Rev B



- ▶ **Long-Term Evolution (LTE)**
 - LTE launched in **North American** on September **2010** with the Samsung SCH-R900
 - Deployed on both **GSM** and the **CDMA** mobile operators



EV-DO Rev B



- ▶ Long-Term Evolution (LTE)
 - Peak Data Rate (Release 8)
 - Downlink: **300 Mbps**
 - Uplink: **75 Mbps**



LTE-A



- ▶ **LTE-A (LTE-Advanced)**
 - Considered as a **4G** technology based on the ITU-R IMT-Advanced process
 - **Peak Data Rate (Release 10)**
 - Downlink: **3 Gbps**
 - Uplink: **1.5 Gbps**



LTE-A



➤ LTE-A (LTE-Advanced)

- LTE-A incorporates **higher order MIMO** (4×4 and beyond) and allows **multiple carriers to be bonded** into a single stream



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