

Challenges for Broadband Wireless Systems

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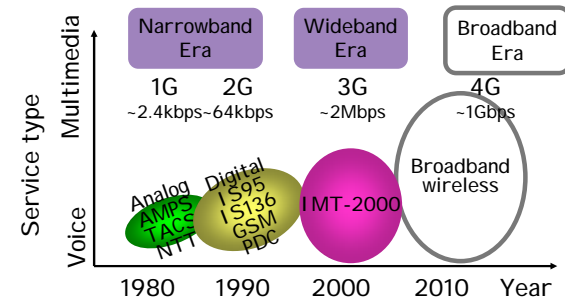
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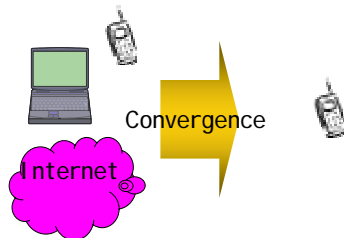
- Evolution of Cellular Systems
- Global Wireless System
- Challenges for Giga-Wireless Technology

Evolution of Cellular Systems

‡ New systems appeared every decade according to advancements in wireless technology and changes in user demands.



Convergence of Wireless, Computing and Internet is on the Way

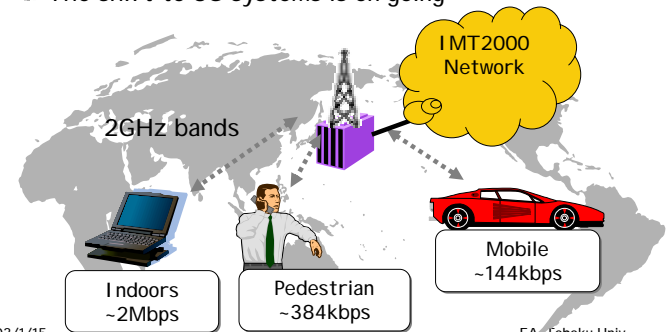


‡ "i-mode" type cellular phones @ Sept. 2002

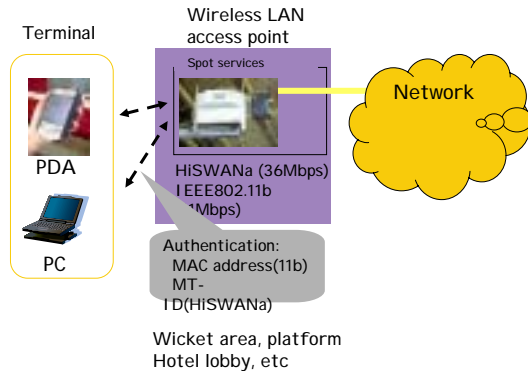
- Cellular users: 72,081,000
- Users connected to Internet: 57,112,700 (79.2%)
 - i-mode: 34,883,000
 - Ezweb: 11,150,400
 - J-sky: 11,079,300

3G Services Started in Japan

- ‡ Introduction of IMT2000 services took place in Japan in 2001
- ‡ The shift to 3G systems is on going



Wireless LAN Trial in Japan



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- ✦ WLAN standards: HiSWANa and IEEE802.11b
 - Significantly higher data rates of 36~54Mbps
 - A shorter-range coverage (100~150m but 500m~1km in LOS condition) than 3G cellular systems

	HiSWANa	IEEE802.11b
Frequency band	5.2GHz	2.4GHz
Modulation	Coded OFDM	Spectrum spreading
Data rate	36Mbps	11Mbps
Multi-access	TDMA-TDD/DSA (centralized control)	CSMA/CA (de-centralized control)
Coverage	~100m	~100m
Network interface	Ethernet/IP/ATM/IMT2000	Ethernet
Authentication	MT-ID	MAC address

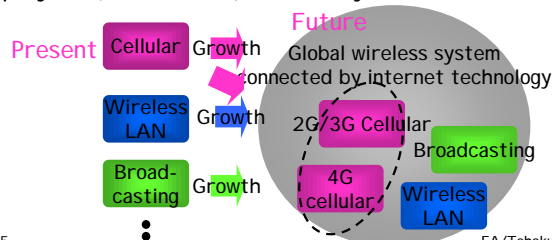
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Global Wireless System

- ✦ Next generation wireless systems may not be based on a single standard, but a global wireless system that consists of many dedicated wireless systems interconnected by broadband Internet technology
- ✦ CRL has initiated the new generation mobile network project (2002~2005) headed by Prof. F. Adachi



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- ✦ Global wireless system to provide nationwide coverage by using different wireless systems
 - Hot spot areas with high multimedia traffic can be covered by 4G hot spot access of 100Mbps~1Gbps or wireless LAN
 - Relatively wide hot spot areas are covered by 4G cellular of ~100Mbps
 - Other places can be covered by present 2G/3G cellular systems
- ✦ Giga-wireless technology
 - Common wireless technology for cellular and wireless LAN applications
 - Data rates of ~1Gbps
 - Very high spectrum efficiency of 5~10 bps/Hz; multiple-input multiple-output (MIMO) antenna systems will play an important role

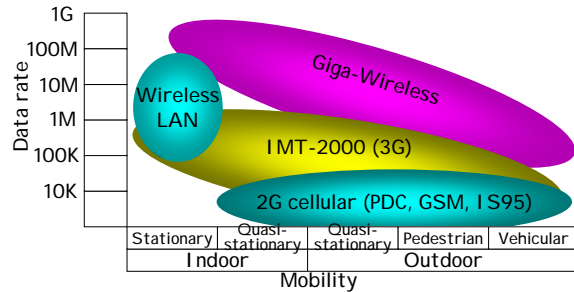
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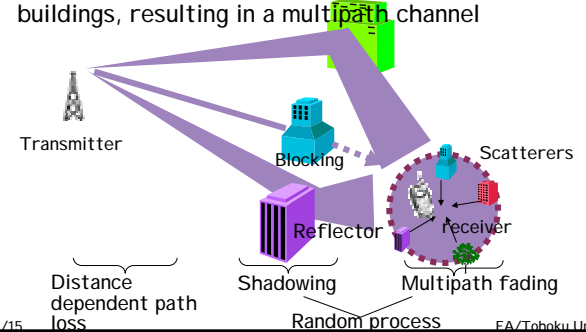
Challenges for Giga-Wireless Technology

- Giga-wireless is one of the core technologies for realization of global wireless system

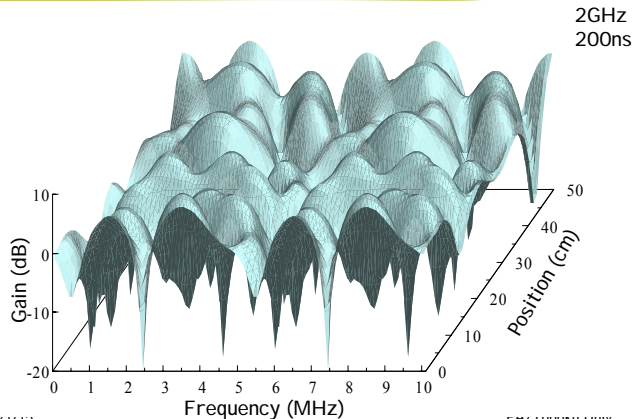


Wireless Propagation Channel Model

- Understanding of propagation mechanism is important for system development
- Transmitted signal is reflected and diffracted by buildings, resulting in a multipath channel

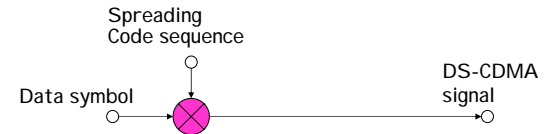


Frequency-Spatial Distribution of Multipath Fading

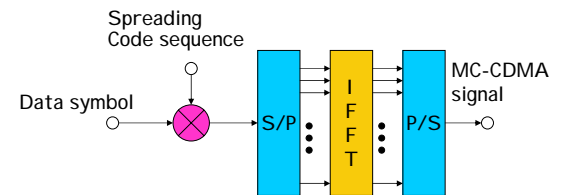


Two Approaches for Giga-Wireless

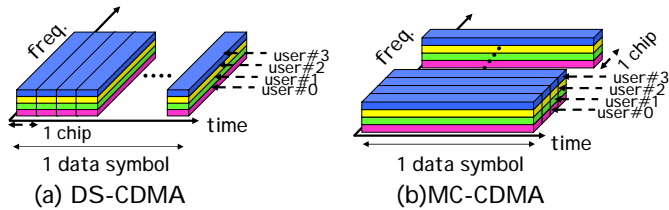
- DS-CDMA: Time domain spreading



- MC-CDMA: Frequency domain spreading

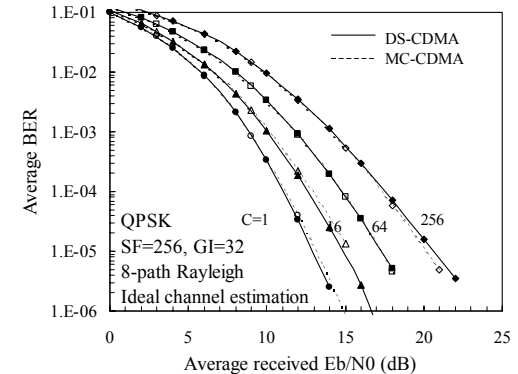


DS-CDMA vs. C-CDMA



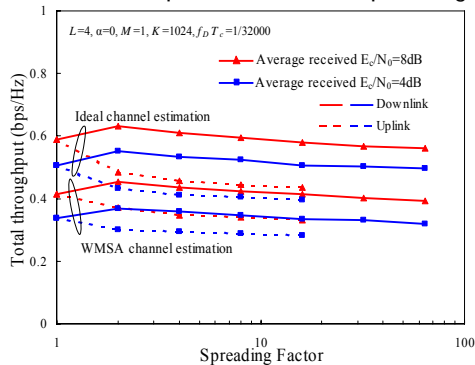
BER Performance

DS- and MC-CDMA provide similar performance



Throughput

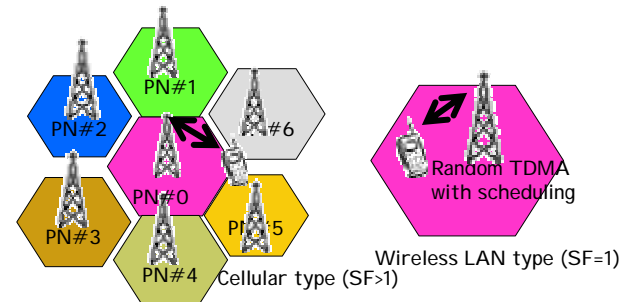
- Hybrid ARQ combined with powerful turbo coding
- Throughput is almost independent of the spreading factor



RCPT HARQ using DS-CDMA

DS- and MC-CDMA Wireless Access systems

Either DS- or MC-CDMA can be a common wireless technology for construction of cellular and hot spot systems

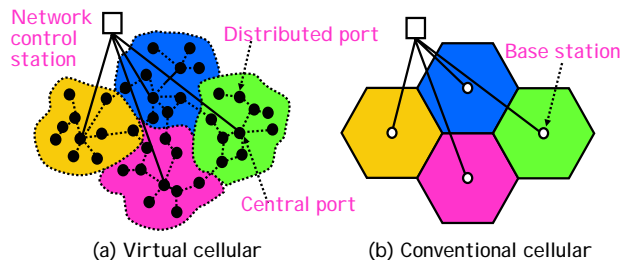


- Cellular type (SF>1)
 - Real time and non-real time services with relatively low data rate per user
- Wireless LAN type (SF=1)
 - Hot spot areas
 - Non-real time services with very high data rate per user are provided by random TDMA system with appropriate scheduling.
 - An SF=1 system can be extended to a cellular system with the aid of fast selection of transmit cell and adaptive antenna array.

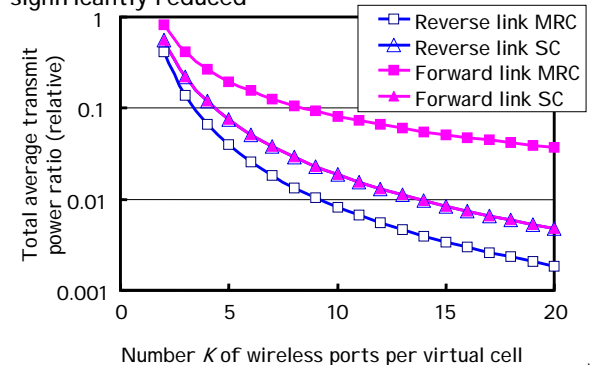
Virtual Cellular System

- Links for 100Mbps~1Gbps becomes not only interference limited but also severely power limited
 - Propagation loss is in proportion to $f^{2.6} \times$ transmission rate
 - Peak transmission power for 100Mbps@5GHz is about 135,000 times that of 8kbps@ 2GHz, e.g., 1W --> 135kW. This cannot be allowed
 - Cell size should be reduced by about 29 times (pico-cell, e.g., 1,000m --> 34m cell)
- Fundamental change in wireless access network architecture is required that allows significant reduction in mobile transmit powers

- Virtual cell consisting of many distributed wireless ports for non-real time IP packet transport
 - Transmit and receive functions are not necessarily installed at all wireless ports
 - Receive-only ports in addition to receive and transmit ports

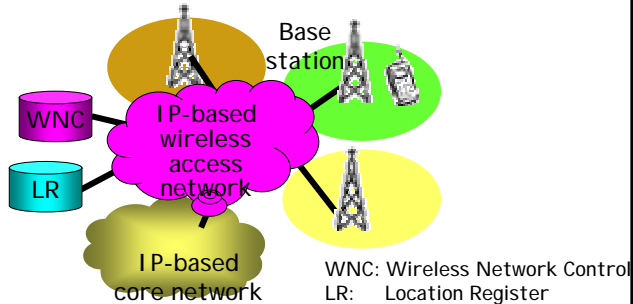


- Total average transmit power per virtual cell can be significantly reduced



Wireless Access Network

- Wireless access network may become closer to present wireless LAN but with nationwide mobility management

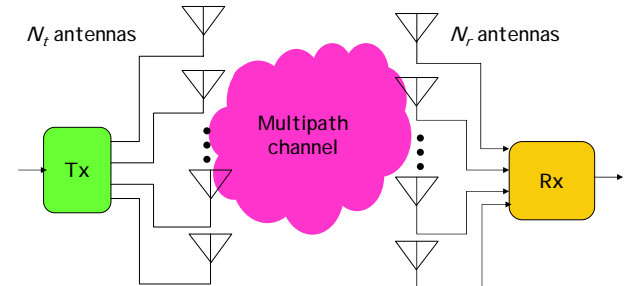


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Advanced Antenna Technology

- Adaptive antenna array (AAA) system
- Space-time Transmit Diversity (STTD) system
- Multi-input/multi-output (MIMO) antenna system

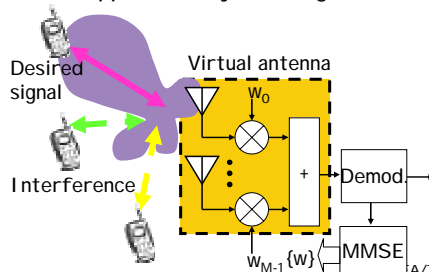


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AAA System

- AAA system confines the transmitting radio energy in a narrow angle width to increase the link capacity in **no. users/Hz** and cellular capacity in **no. users/Hz/m²**
- Interference from other users located at different positions are suppressed by forming narrow beams

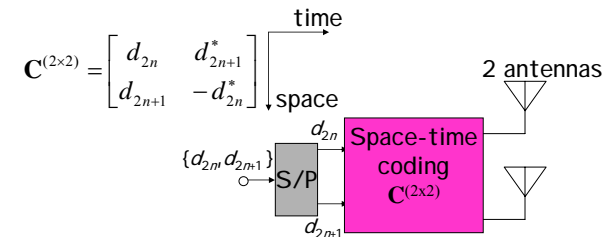


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STTD System

- STTD system exploits independent fading seen on different transmit antennas to improve the transmission quality in **BER or FER**
- Simple example is Alamouti's STTD, that can achieve MRC diversity improvement with 3dB power penalty

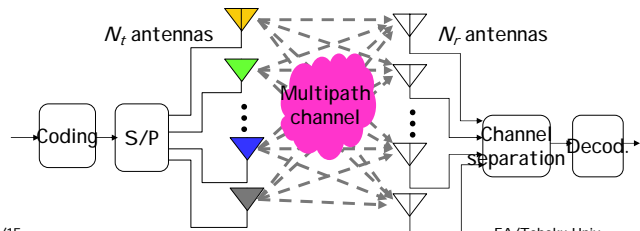


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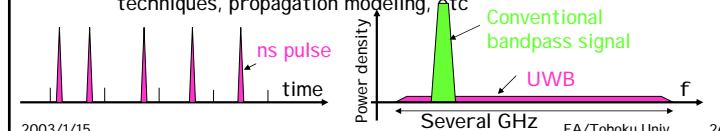
MIMO System

- ✦ MIMO antenna system transmits different data sequences from different antennas to increase achievable data rate within the limited bandwidth, i.e., the channel capacity in **bps/Hz**
- ✦ If 8 antennas are used with QPSK transmission, then 16bps/Hz can be achieved



Another Interesting Wireless Technology: UWB

- ✦ Ultra wideband (UWB) technology for short range communication (several tens meters) has been attracting a strong attention
- ✦ Possible applications: Personal area network, home area network, computer commun., adhoc network
- ✦ CRL has initiated UWB project (2002~2005) headed by Prof. R. Kohno
 - >100Mbps UWB communications system using 3-30GHz and >30GHz
 - Devices, pulse signal processing, interference suppression techniques, propagation modeling, etc



Conclusion

- ✦ Wireless systems are now becoming an important infrastructure of our society.
- ✦ A global wireless system was suggested to offer broad ranges of Internet services to cellular and nomadic users
 - Many dedicated wireless systems are efficiently interconnected, including 2-4G cellular systems, wireless LANs, broadcasting systems, etc., each optimized to each communications environment
- ✦ Common wireless technology is desirable to be used in 4G cellular and wireless LAN type systems
 - Either DS- or MC-CDMA can be used
- ✦ Wireless technology of 100M-1Gbps capability is a challenging research for the coming 10 years