

# Broadband Mobile Technology

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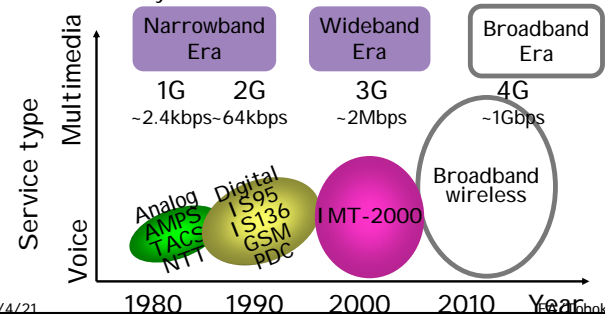
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## OUTLINE

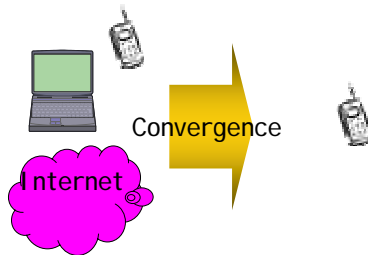
- Evolution of Cellular Systems
- Global Wireless System
- Challenges for Giga-Wireless Technology

# Evolution of Cellular Systems

- Our ultimate goal is to communicate any type of information with anyone, at anytime, from anywhere. This is only possible with the aid of wireless technology.
- Wireless systems are now becoming an important infrastructure of our society.



# Convergence of Wireless, Computing and Internet is on the Way

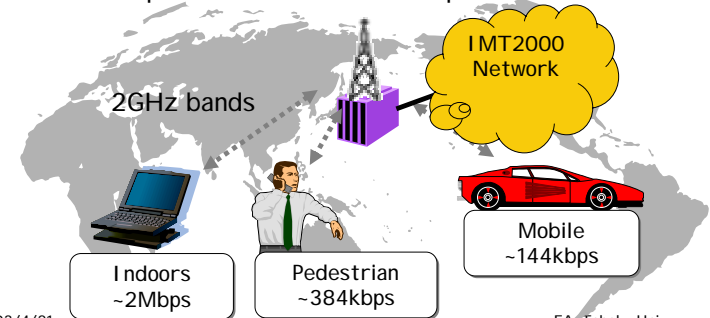


“i-mode” type cellular phones @ Feb. 2003

- Cellular users: 74,368,600
- Users connected to Internet: 60,946,100 (82.0%)
  - i-mode: 36,931,000
  - Ezweb: 12,131,900
  - J-sky: 11,883,200

# 3G Services Started in Japan

- The shift to 3G systems is on going. Introduction of IMT2000 services took place in Japan in 2001
- High-speed downlink packet access (HSDPA) of 8~10Mbps/5MHz is under development.

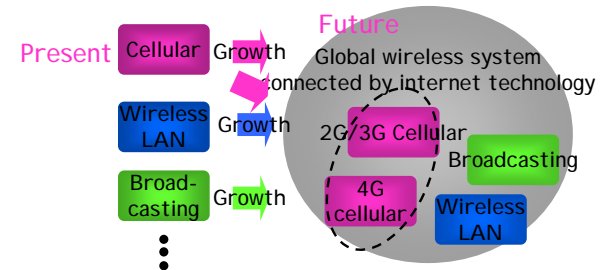


# Evolution of cellular systems

|                 | 1G               | 2G                            | 3G                               | 4G  |
|-----------------|------------------|-------------------------------|----------------------------------|---|
| Wireless Access | Analog           | Digital                       | Digital                          | Up to 1 Giga bit/s<br>OFDM, CDMA based access |
| Major Services  | Voice            | Voice<br>Internet (text only) | Voice<br>Internet (text, images) | Broadband rich Internet                       |
| Core-network    | Circuit-switched | Circuit-and packet switched   | Circuit-and packet switched      | Broadband IP-based                            |

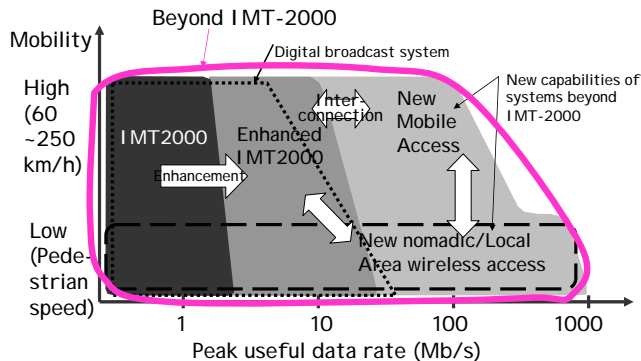
# Global Wireless System

- 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



# Future vision, ITU-R WP8F (Ottawa, June 2002)

- Software defined radio may play an important role



- Global wireless system to provide nationwide coverage by using different wireless systems

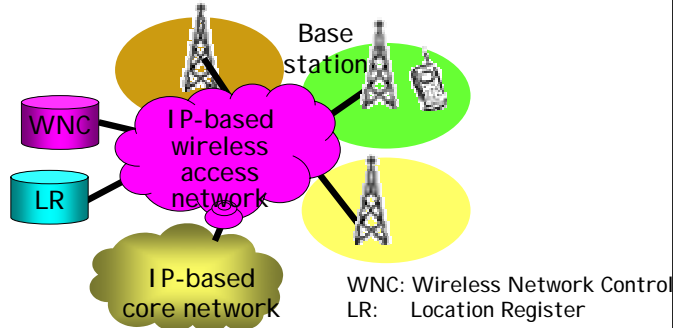
- Hot spot areas with high multimedia traffic can be covered by hot spot wireless access (wireless LAN type) of 100Mbps-1Gbps
- Relatively wide hot spot areas are covered by 4G cellular of ~100Mbps
- Other places can be covered by present 2G/3G cellular systems

- Giga-wireless technology

- Common wireless technology for cellular and wireless LAN type applications
- Very high spectrum efficiency of 5-10 bps/Hz is required for 1Gbps transmission over 100MHz bandwidth; multiple-input multiple-output (MIMO) antenna systems will play an important role

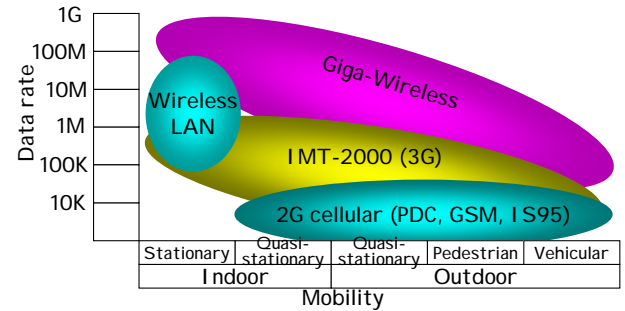
# Wireless Access Network

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



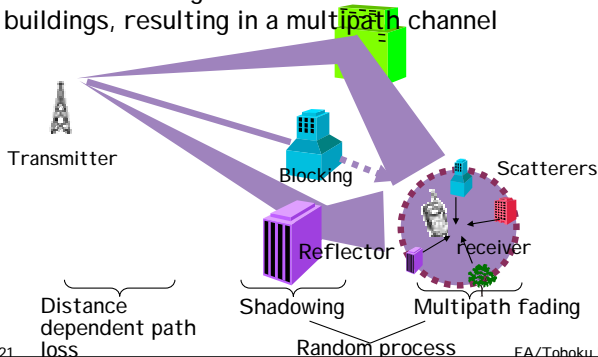
# Challenges for Giga-Wireless Technology

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

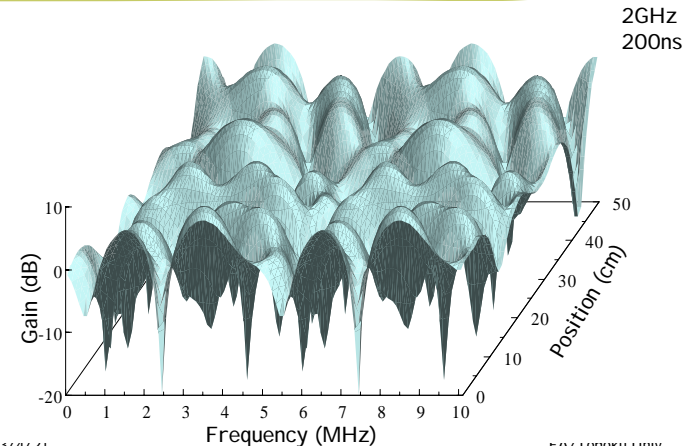


# Wireless Propagation Channel Model

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

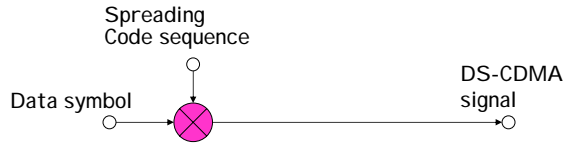


# Frequency-Spatial Distribution of Multipath Fading

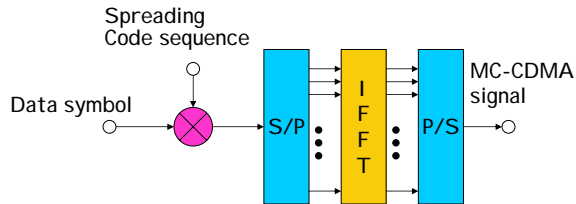


# Two Approaches for Giga-Wireless

## DS-CDMA: Time domain spreading

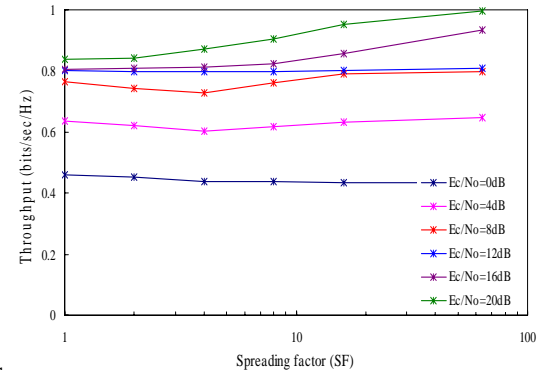


## MC-CDMA: Frequency domain spreading



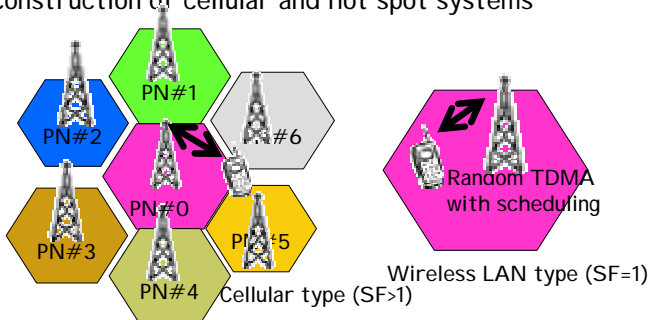
# Packet Throughput vs. SF (no. users = SF)

RCPT Type II HARQ using SP8. MC-CDMA using  $N_c=256$  and BPSK.  $K=1024$ bits.  $L=16$ ,  $f_d T_0=0.01$



# Wireless Access systems

A common wireless technology is desirable for construction of cellular and hot spot systems



H. ATARASHI, S. ABETA, M. SAWAHASHI, "Variable Spreading Factor-Orthogonal Frequency and Code Division Multiplexing (VSF-OFCDM) for Broadband Packet Wireless Access," IEICE Trans. Commun., Vol.E86-B No.1 pp.291-299, Jan. 2003

## Cellular type (SF>1)

- Real time and non-real time services with relatively low data rate per user

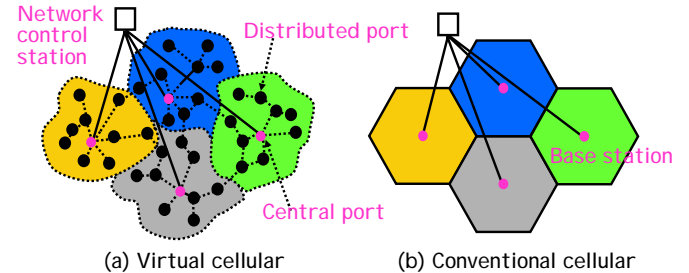
## Wireless LAN type (SF=1)

- 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.

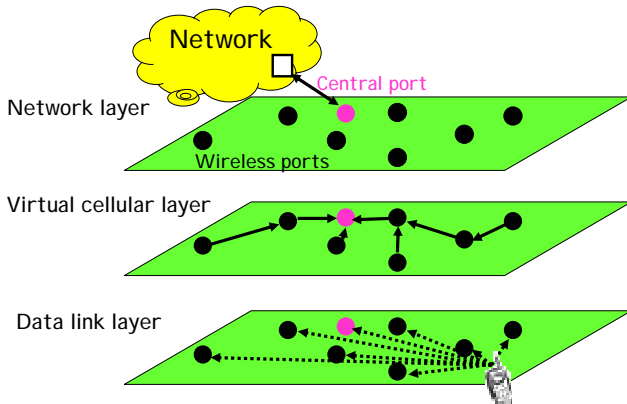
# Virtual Cellular System

- Links for 100Mbps~1Gbps becomes not only interference limited but also severely power limited
  - Propagation loss is in proportion to  $r^{2.6} \times$  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

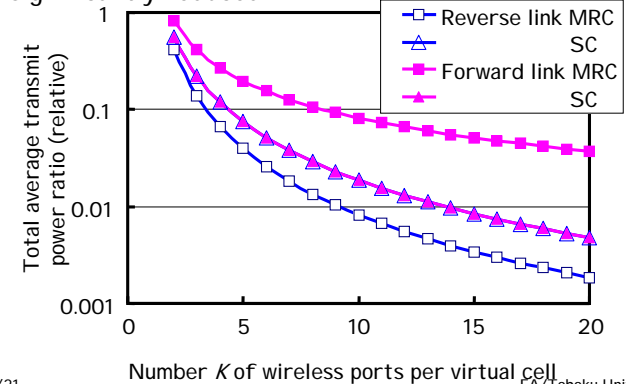
- Virtual cell consisting of many distributed wireless ports for non-real time IP packet transport
  - Transmit and receive functions are not necessarily installed at all wireless ports
  - Receive-only ports in addition to receive and transmit ports



# Virtual cellular system

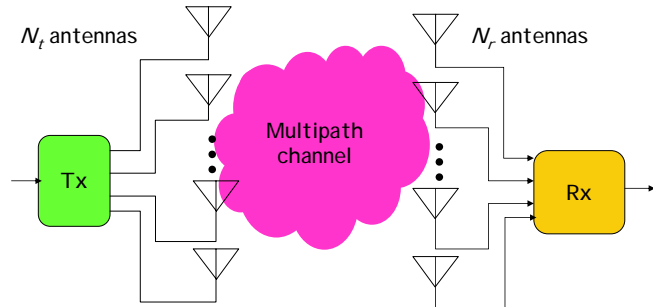


- Total average transmit power per virtual cell can be significantly reduced



# Advanced Antenna Technology

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



# Conclusion

- ✦ A global wireless system was suggested to offer broadband wireless 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
- ✦ Wireless technologies for 4G cellular and wireless LAN type systems
  - Common wireless technology of 100M-1Gbps capability
  - Software defined radio
  - MIMO systems
- ✦ Giga-wireless technology is a challenging research for the coming 10 years