

# **Challenges of Wireless Communications**

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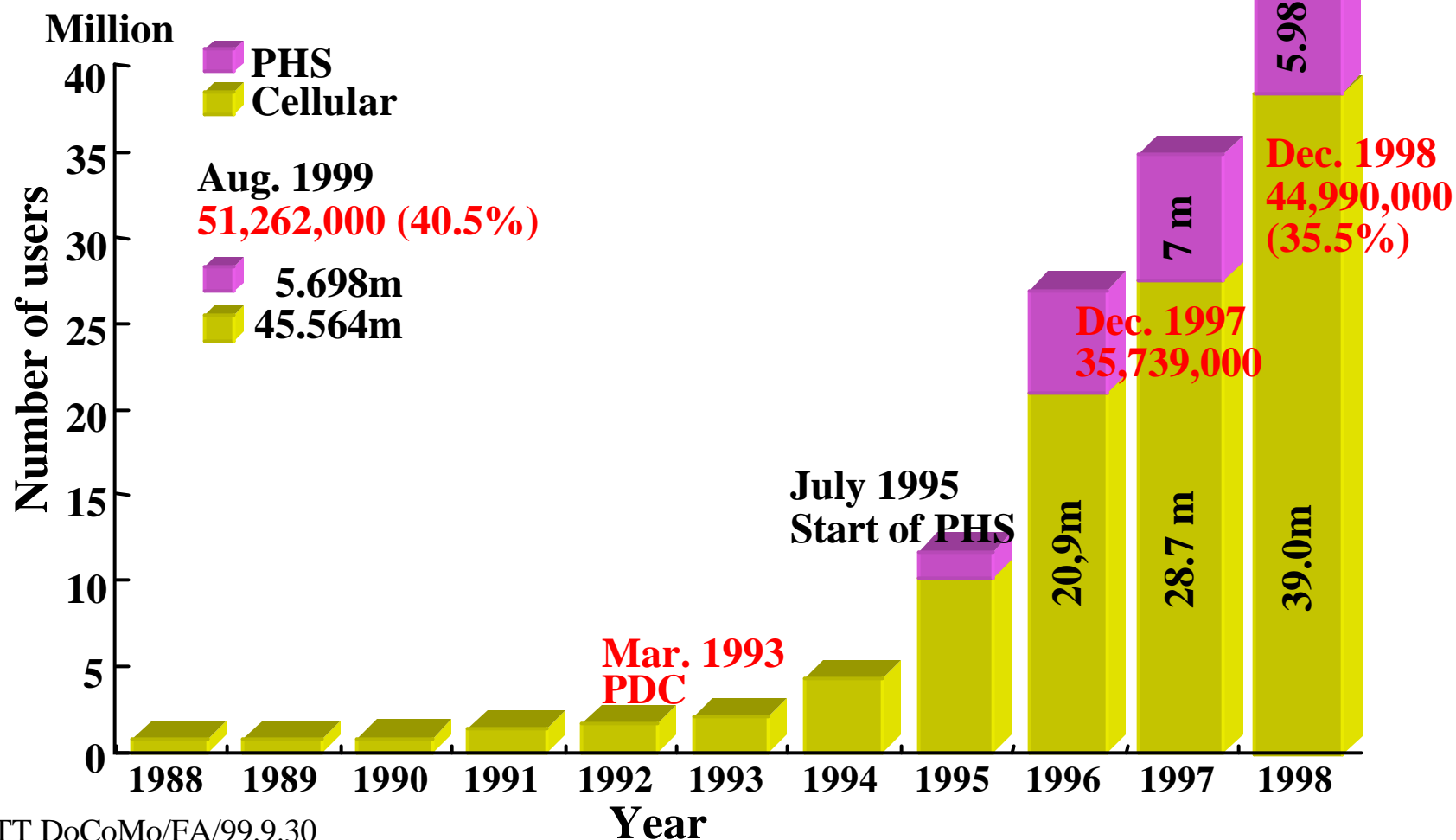
## **Outline**

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- 1. Bridging the Expanse of Mobile Multimedia**
- 2. Trends in Wireless Access Technology**
- 3. Global 3G CDMA**
- 4. Beyond Global 3G**

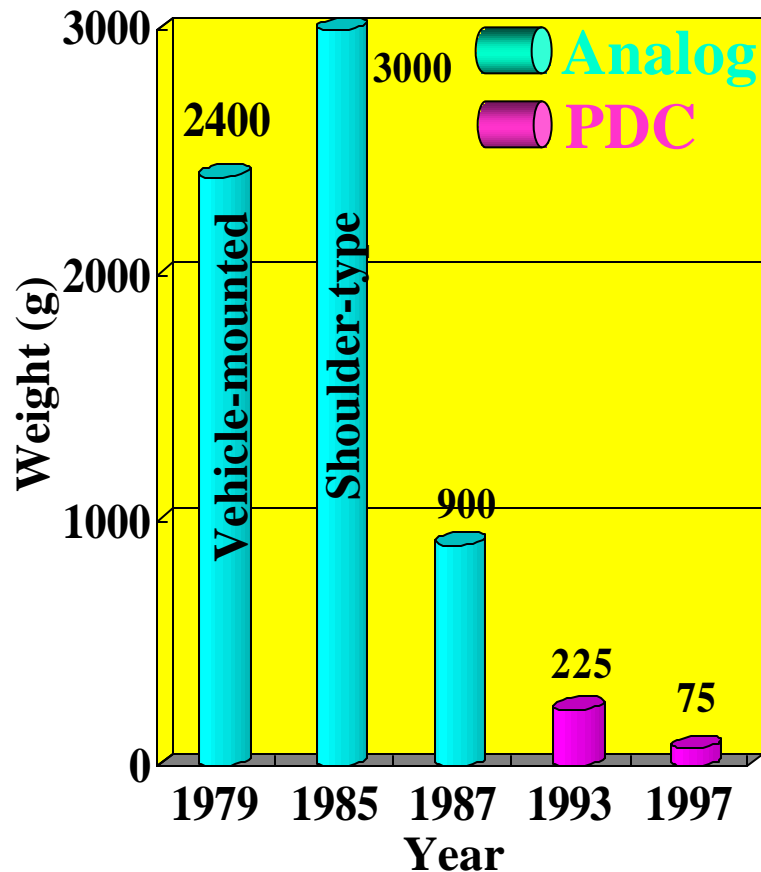
# Growth of Mobile Communications in Japan

- Penetration rate of mobile communications surpassed 40% point and is expected to overtake fixed telephone within a year
- Number of fixed telephone lines has declined to 58million (its peak was 61 million in 1997)

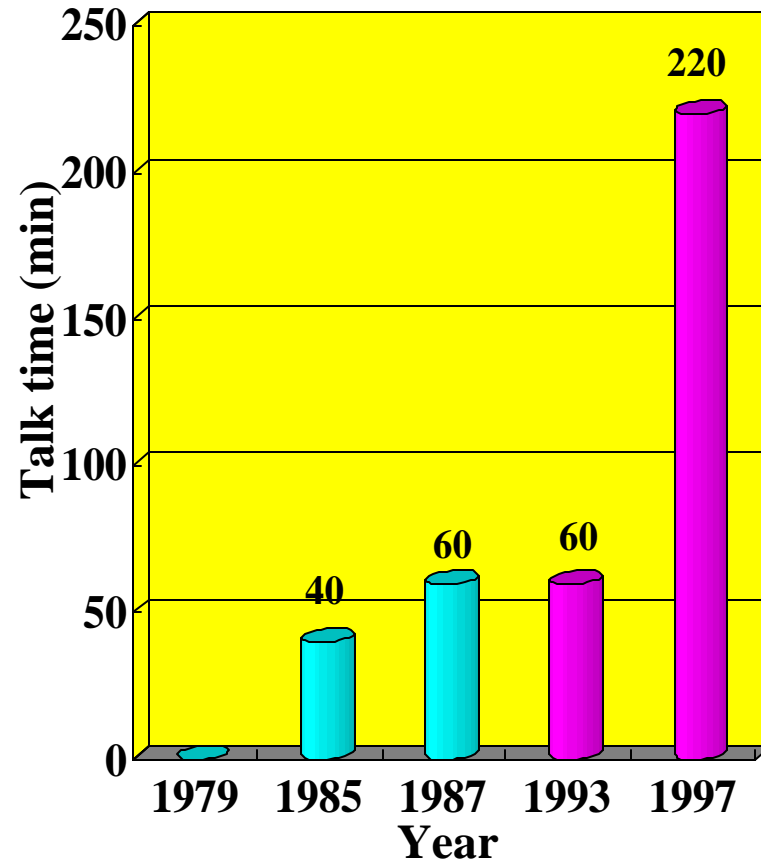


# Weight and Talk Time of Mobile Phones

- Increased utilization efficiency of portable phones is an important factor of gaining popularity of mobile phones



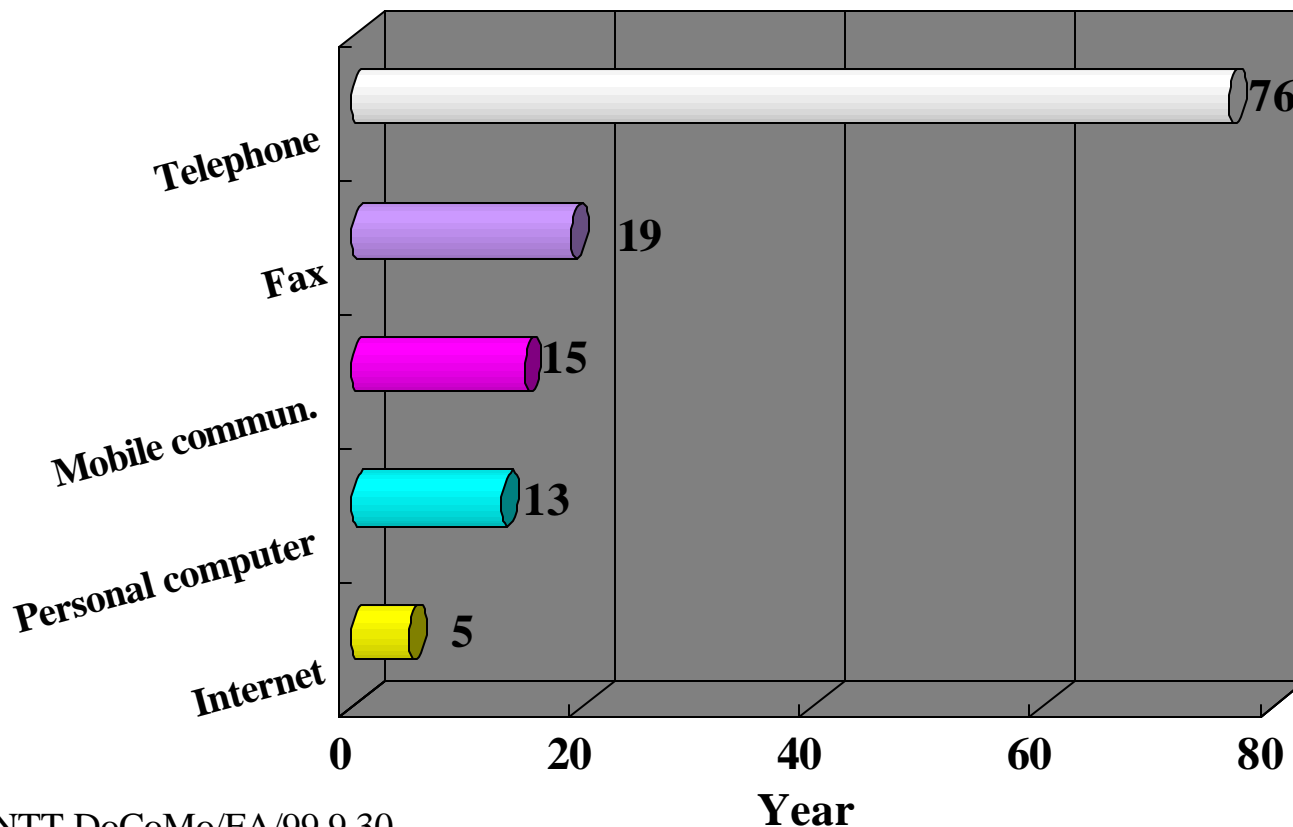
(a) Mobile phone weight



(b) Talk time

# Time Taken to arrive at 10% (house hold) Point

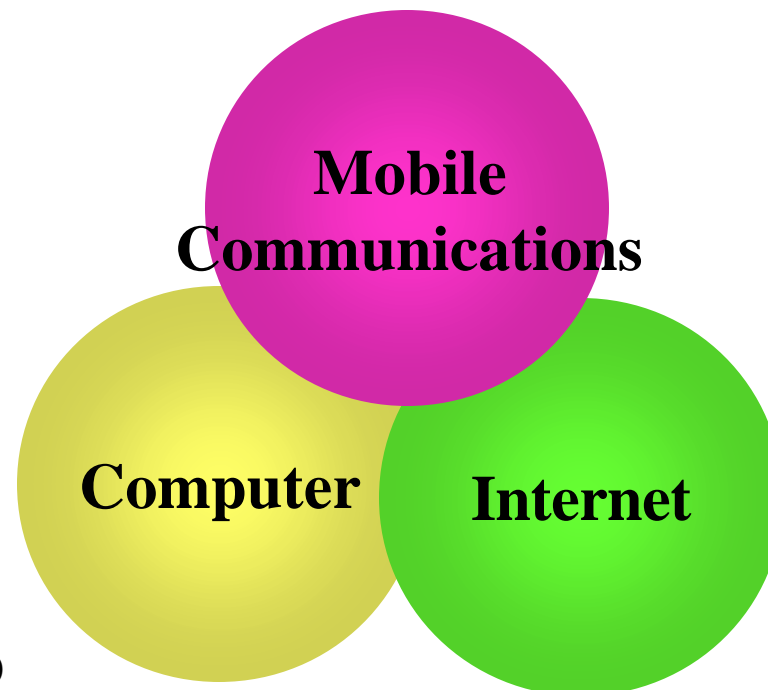
- The rate at which mobile radio and Internet communications services have proliferated throughout our society is striking
- In the fixed networks, voice conversation was a long-time dominant service, but the introduction of Internet communication services is significantly changing our society



Source: Communications White Paper, MPT, 1999

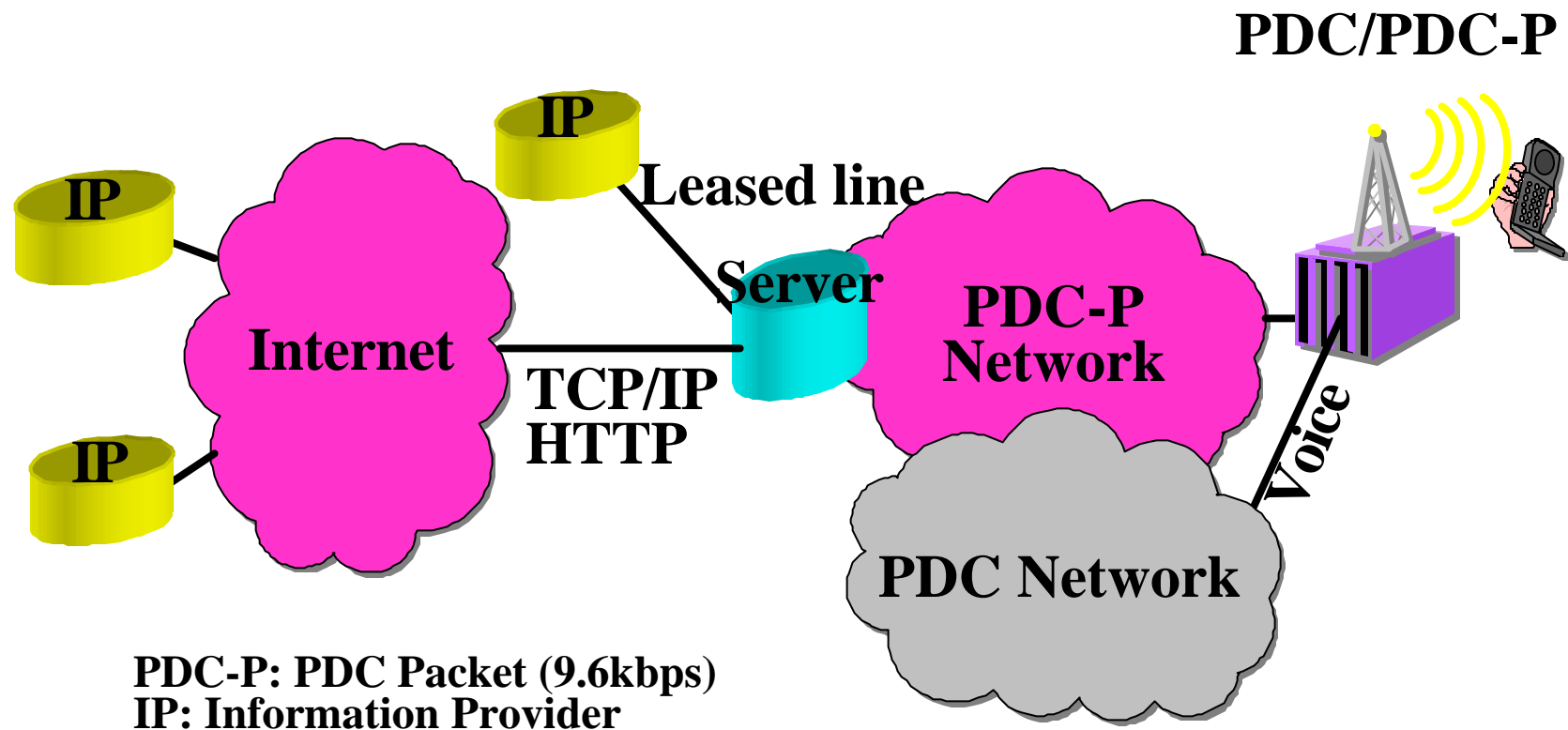
# Evolution to Wireless Multimedia Society

- A combination of mobile communications, personal computers, and Internet services will drive our society to evolve into a wireless multimedia society
- Ultimate goal is to communicate *any information with anyone, at any time, from anywhere*
- Recently, mobile communications services are shifting their focus from only voice conversation to Internet connections in line with the increasing popularity of Internet communications in fixed networks



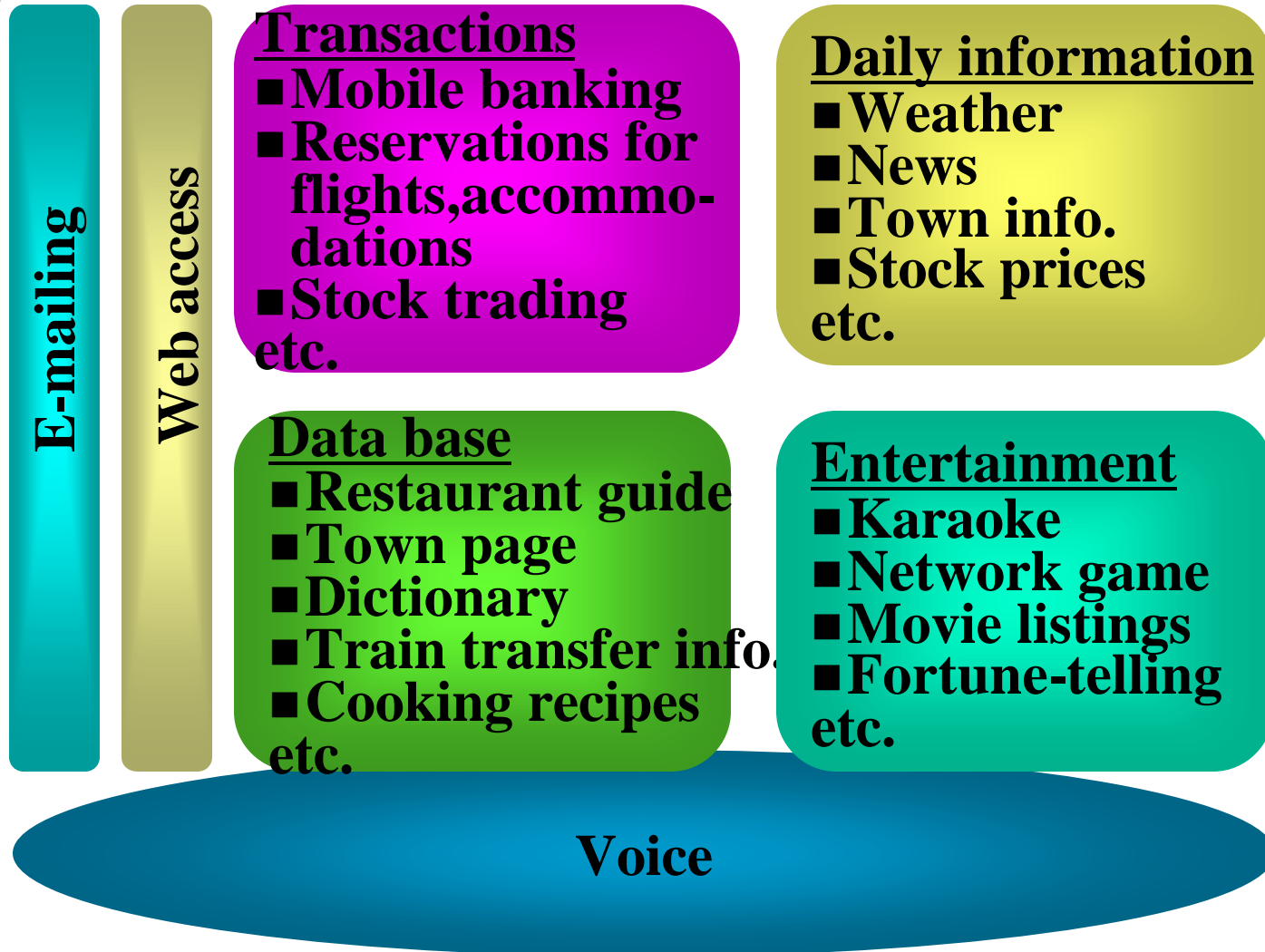
# Multimedia-type “i-mode service” Over PDC-Packet Networks

- The first step toward bridging the expanse from today’s society to wireless multimedia society is seen in a new Internet access service called “i-mode service”



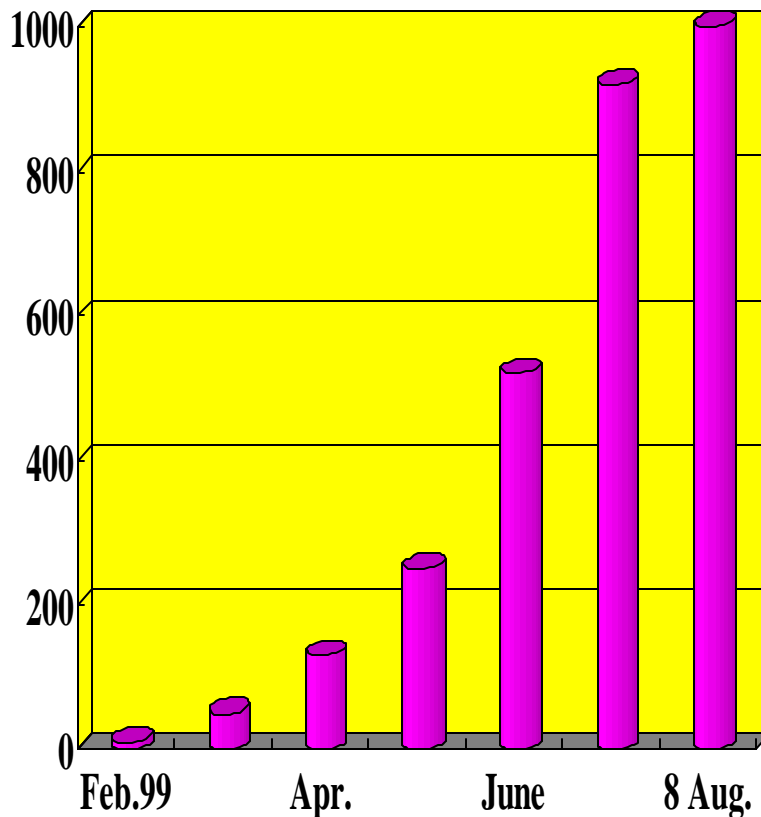
# Contents of “i-mode service”

- “i-mode service” provides e-mailing, web access, various types of on-line services as well as voice conversation

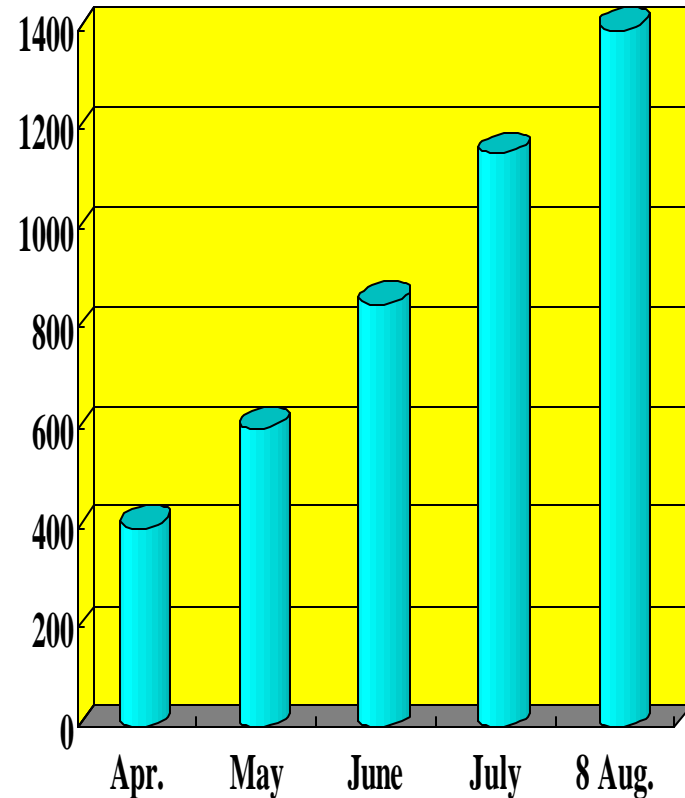


# Rapid Growth of “i-mode service”

- **Rapid growth: one million users in Aug. 1999 after its introduction in Feb. 1999**
- **Accelerating the popularity of “i-mode services” is the increasing number of IP sites (positive feedback): over 1400 in 8 Aug.**



(a) Number of users (x1000)

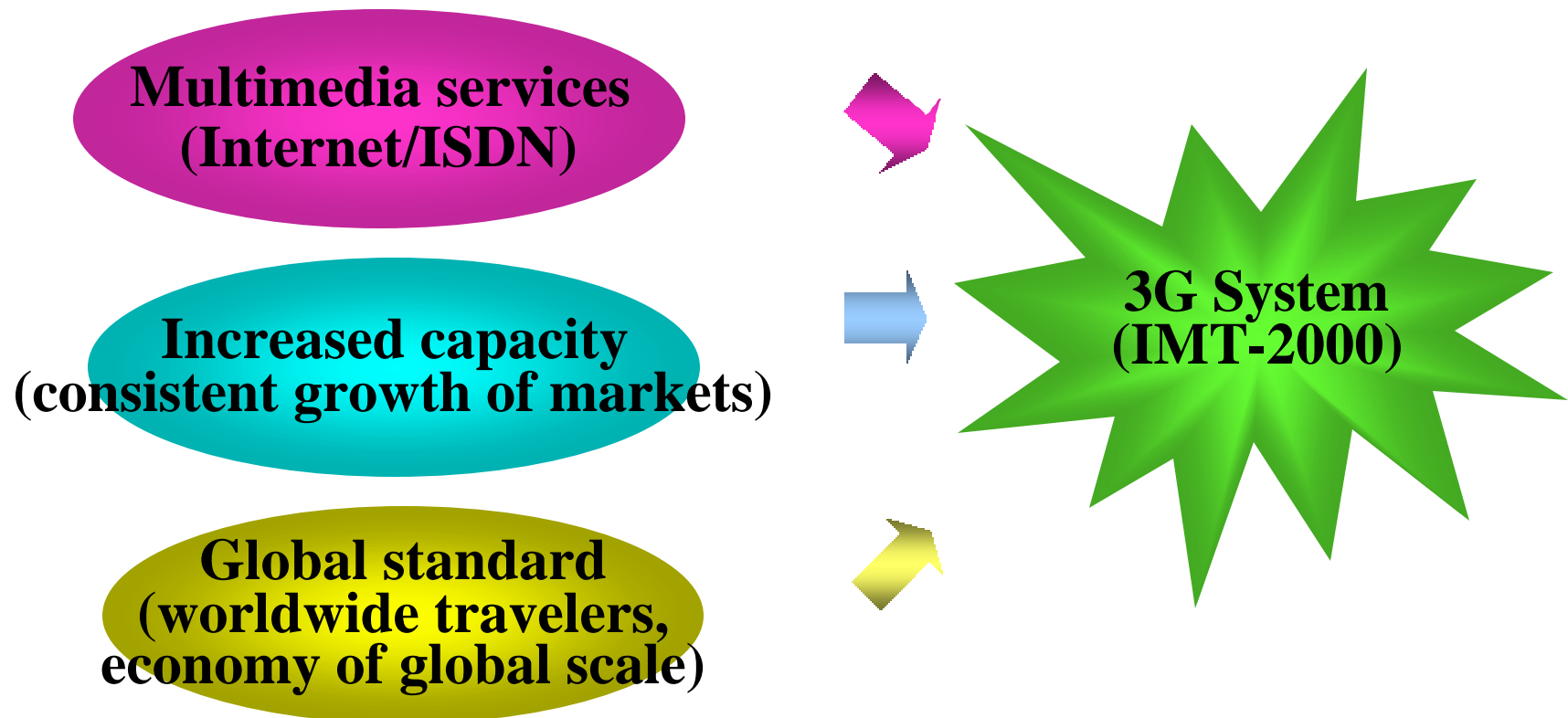


(b) Number of IP sites



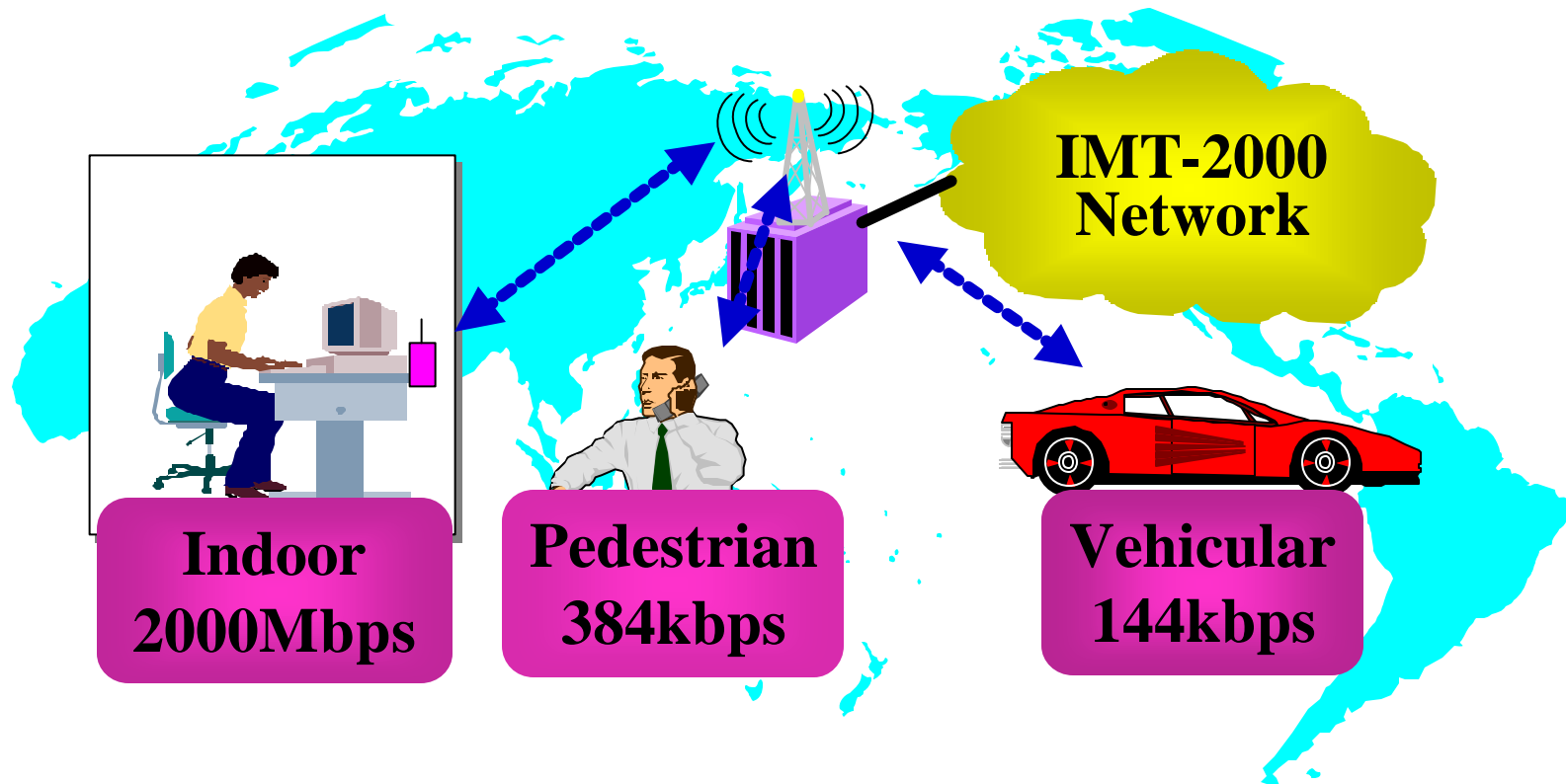
# Preparing for Wireless Multimedia Society

- Major services will shift from voice to multimedia services over Internet indicated by “*i-mode*”, but with much faster transfer rate and much better representation
- Fixed networks Internet traffic will exceed voice traffic in 2001 and 22% of mobile users will use multimedia services in 2000



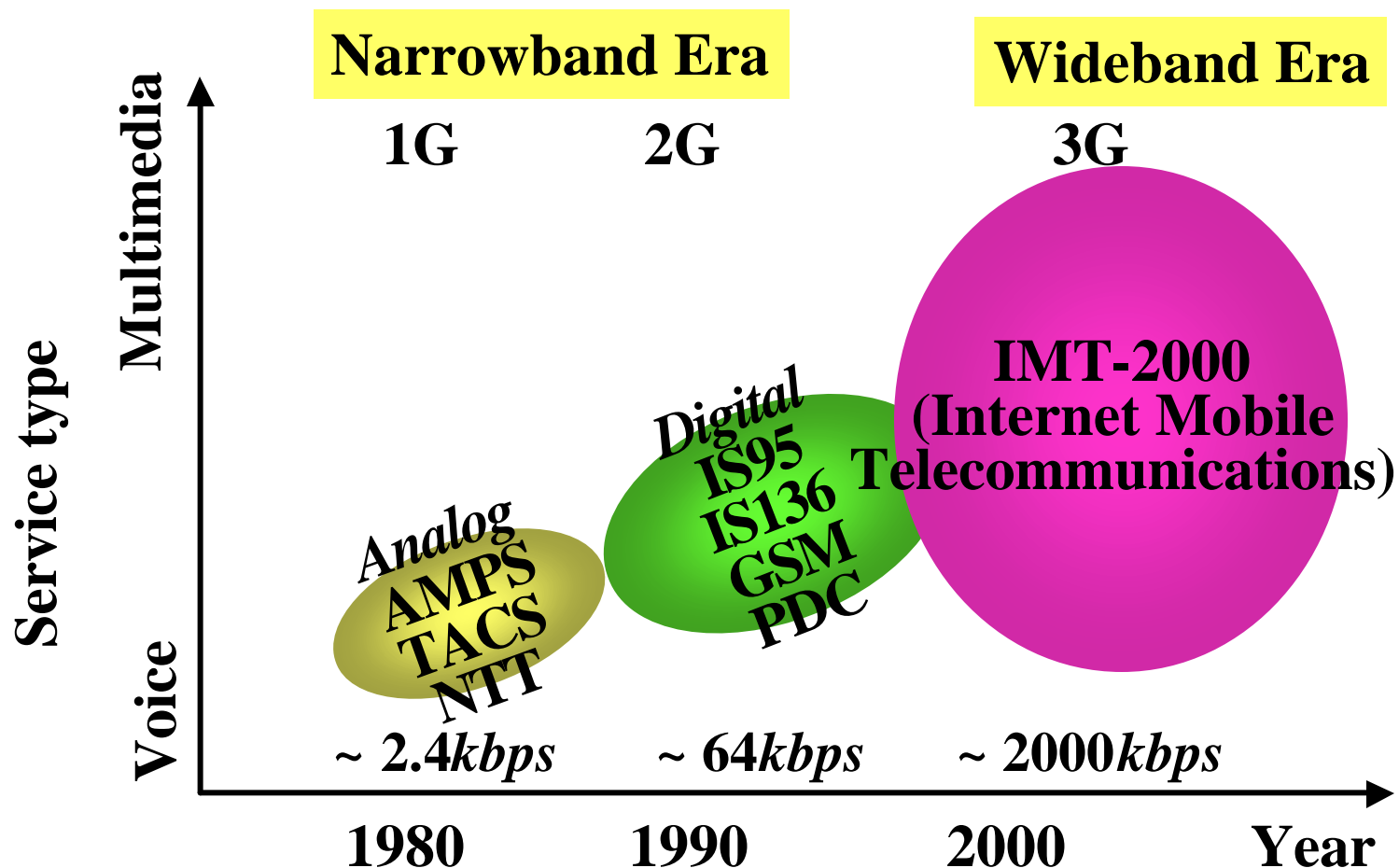
# IMT-2000 Deployment and Capability

- It is expected to be deployed worldwide starting around 2001-2002
- Technical target: information rates of up to 2 Mbps, same quality as fixed networks, use of 2-GHz bands
- “IMT-2000” probably better represents “*Internet Mobile Telecommunications in the years of 2000’s*”



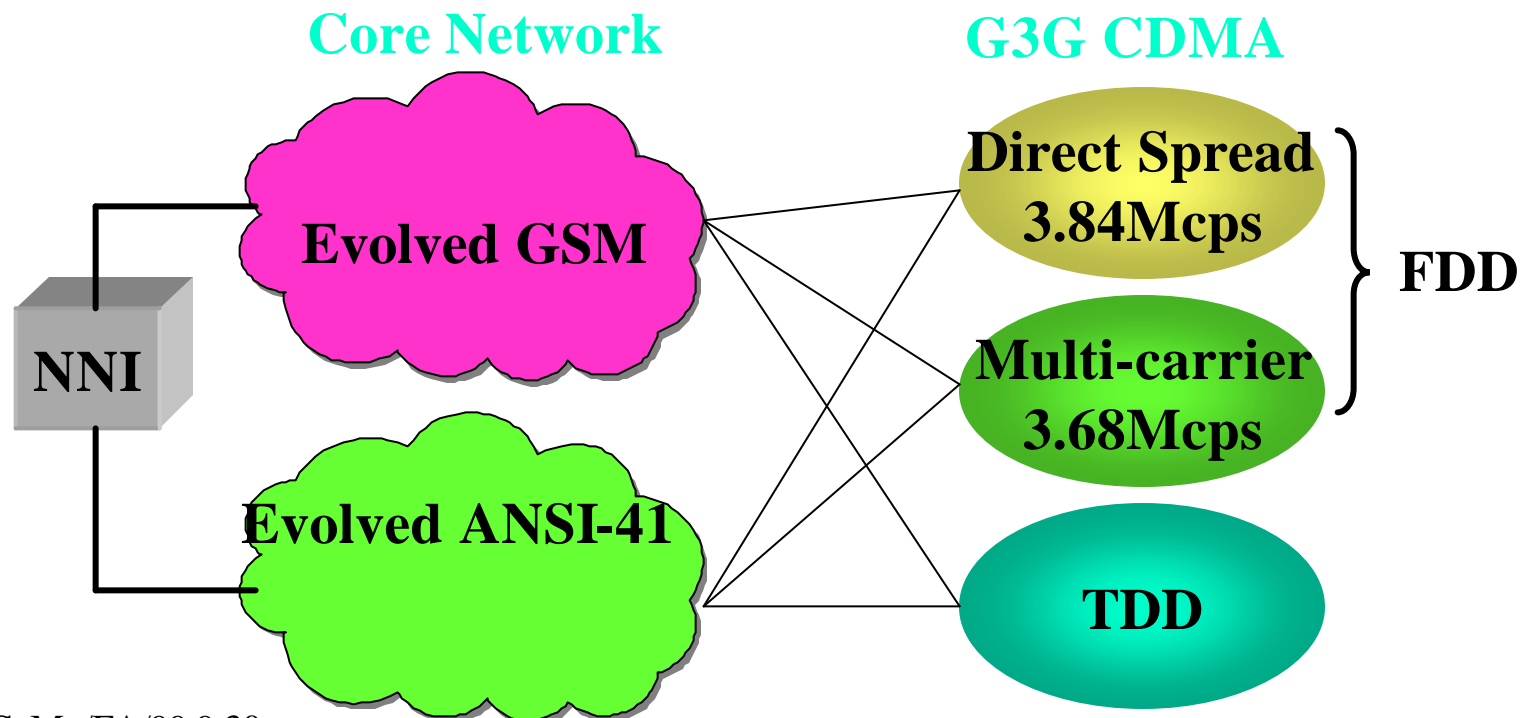
# Evolution Path to Wireless Multimedia Society

- To realize IMT-2000, a new wideband wireless access technique incorporating as many recent technological achievements as possible is necessary



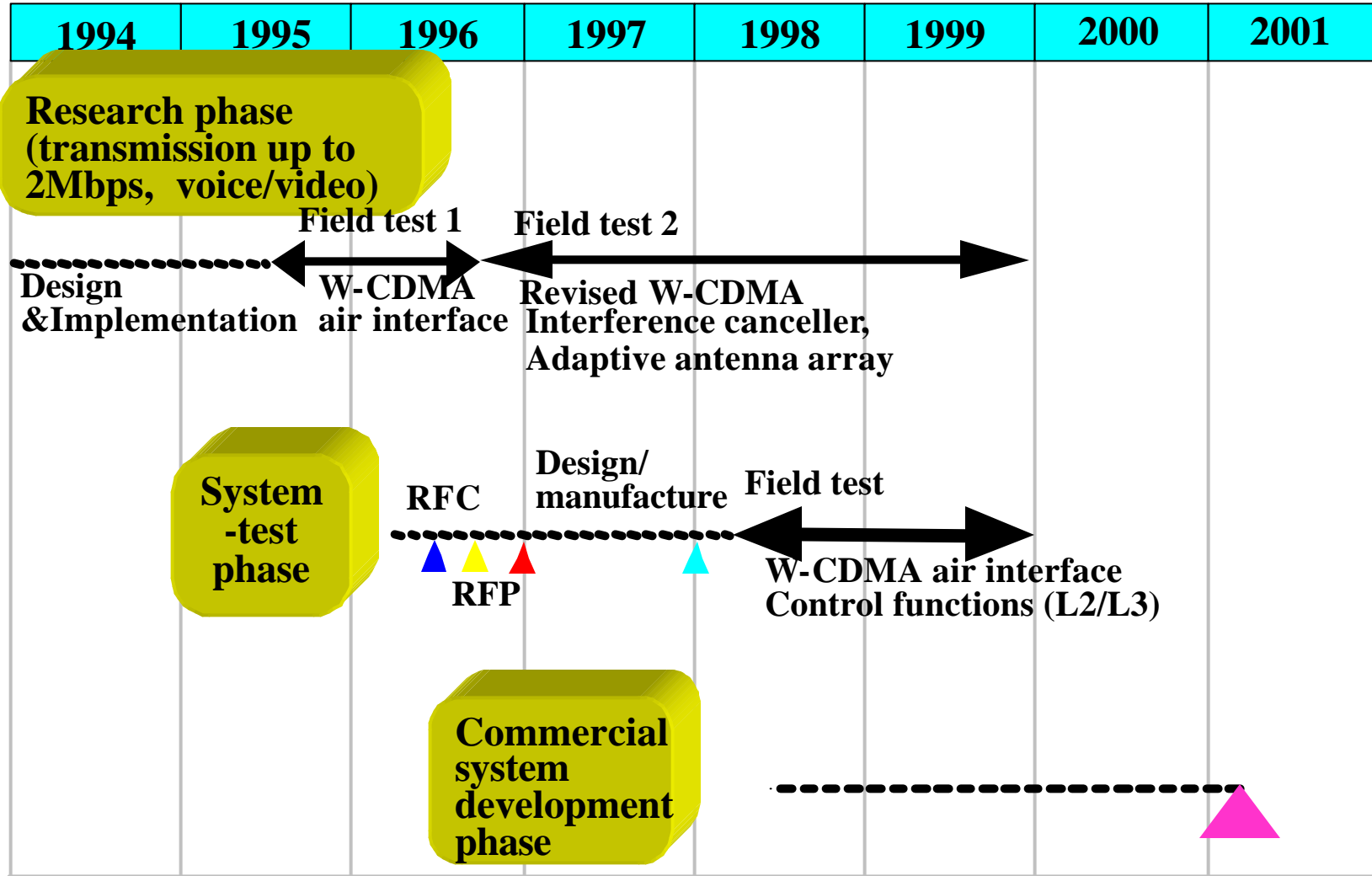
# Harmonization Solution to Global 3G

- 8 out of 10 proposals submitted to the ITU in July 1998 were based on DS-CDMA
  - ✓ TIA: cdma2000
  - ✓ Japan: ARIB started its selection process for a wireless access technique in 1995 and chose W-CDMA in 1997
  - ✓ ETSI: UTRA (W-CDMA for FDD and TD/CDMA for TDD)
- Intensive harmonization studies are currently under way to establish a global 3G standard

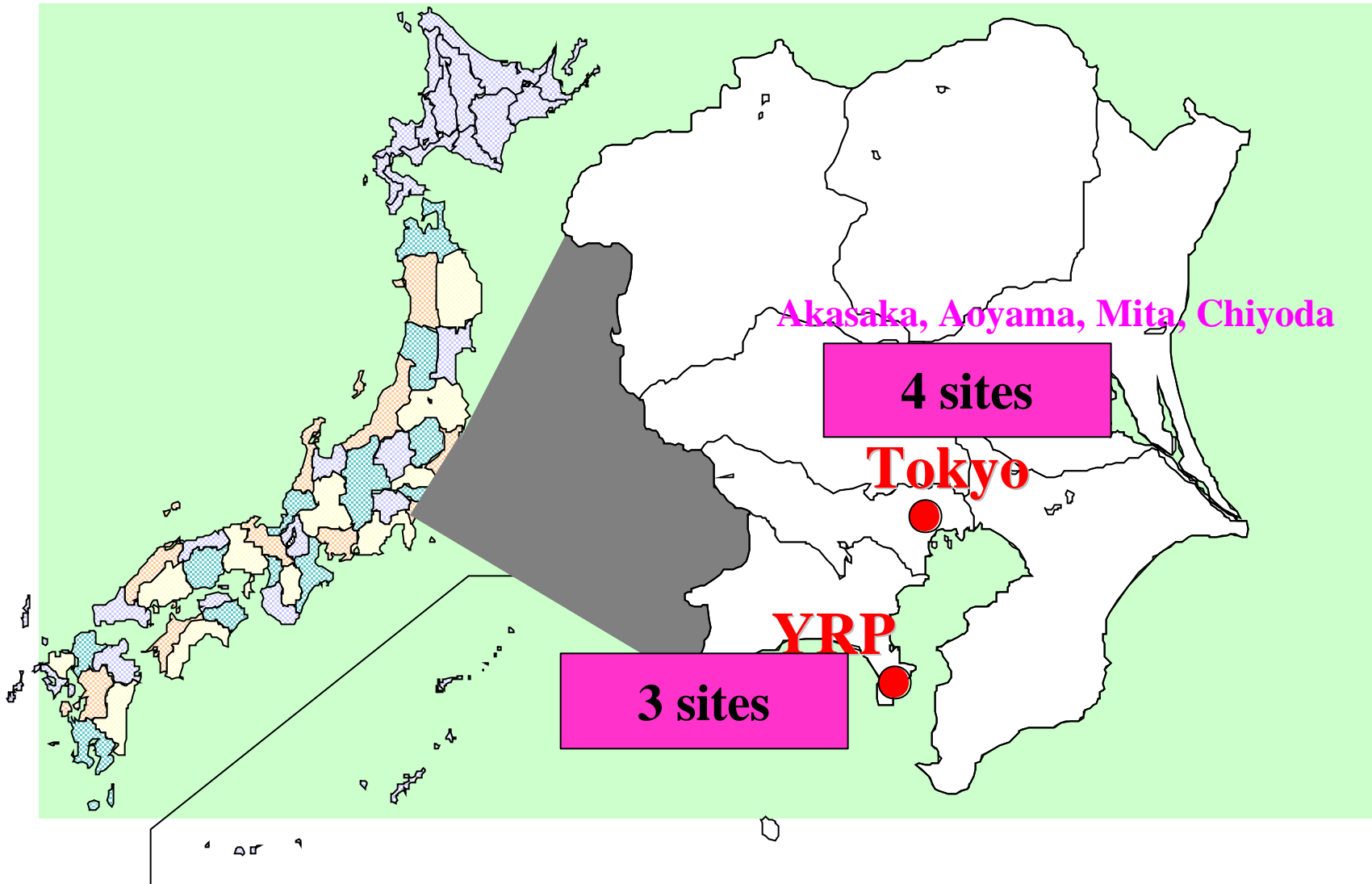


# R&D Plan for IMT-2000

■ Target year of commercial deployment is Mar. 2001

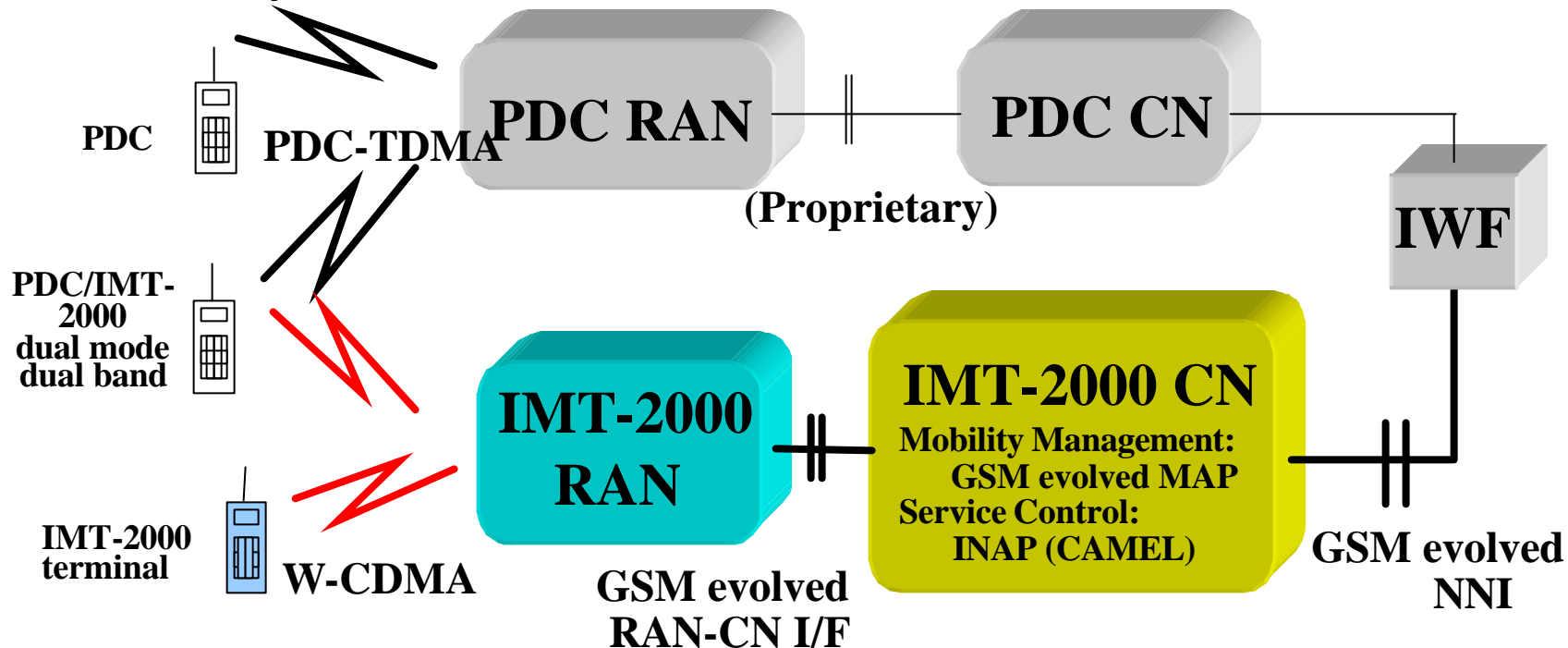


# System Test



# Migration Path Toward IMT-2000

## ■ Overlay of IMT-2000 with PDC



- Service area of IMT-2000 system (IMT-2000 RAN+IMT-2000 CN) will be overlaid with that of existing PDC system (PDC RAN+ PDC CN).
- IMT-2000 CN connects and inter-works with PDC through IWF (inter-working function).
- Initially, IMT2000-PDC dual mode terminal as well as IMT-2000 single mode terminal will be introduced .

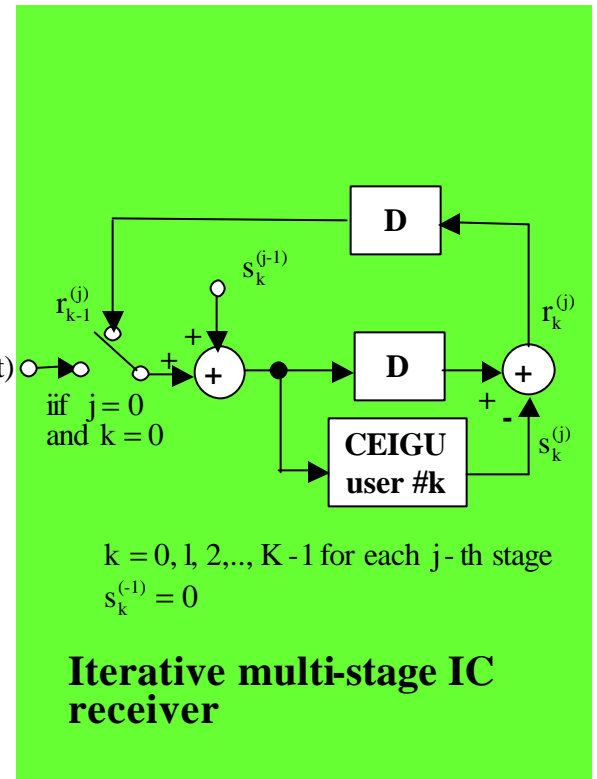
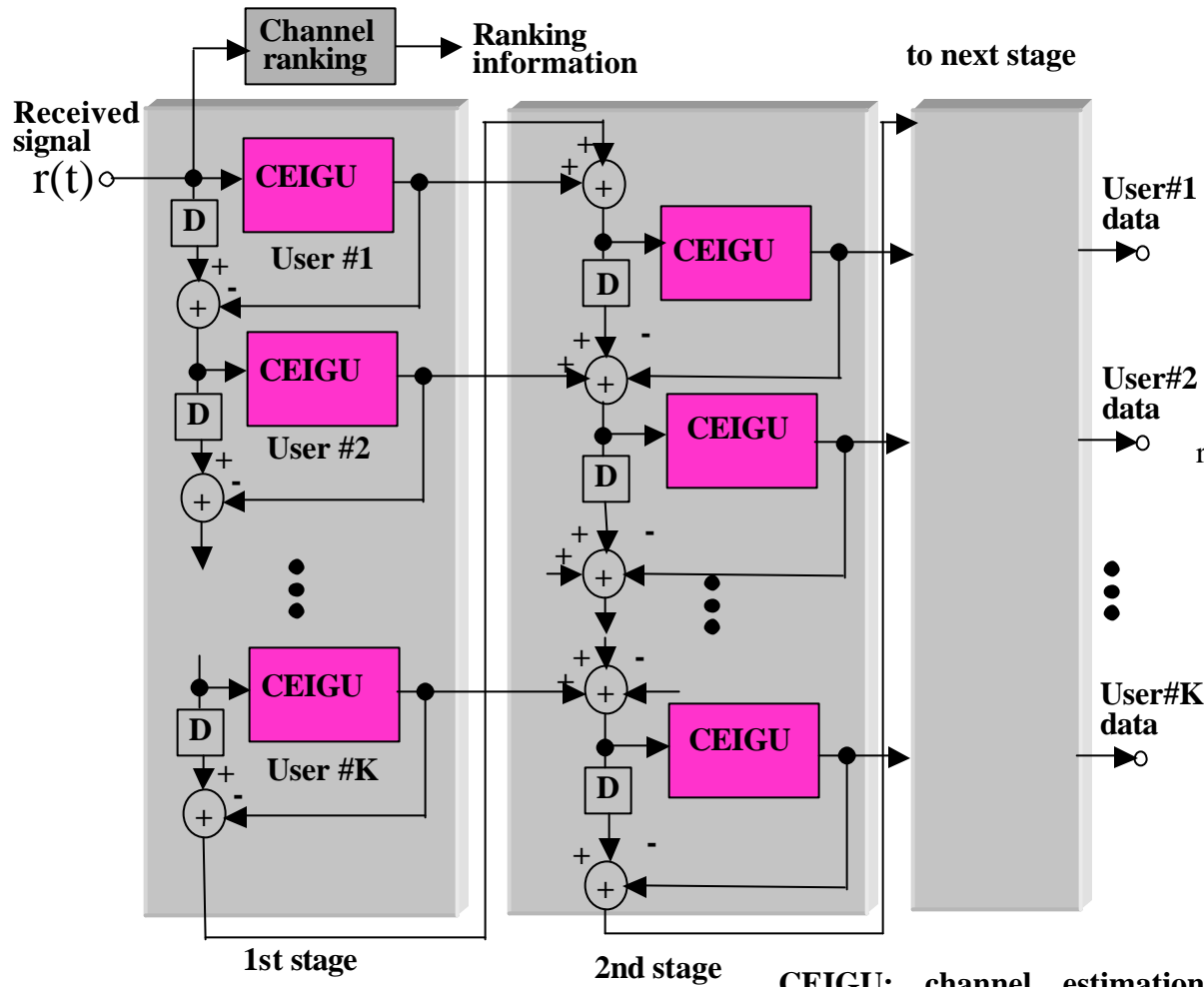
# Advanced Transceivers

- ❑ In a multimedia W-CDMA communications system, link capacity is predominantly limited by high rate users producing severe multi-access interference (MAI)
- ❑ Two promising advanced receivers
  - **Interference canceling (IC) receiver**  
Multi-stage successive IC receiver: Interference subtraction is performed successively for different users in the order of decreasing power, thereby improving SIR for low rate users
  - **Adaptive antenna array receive/transmit diversity**  
Beam is directed toward the desired user while reducing interference particularly from high rate users



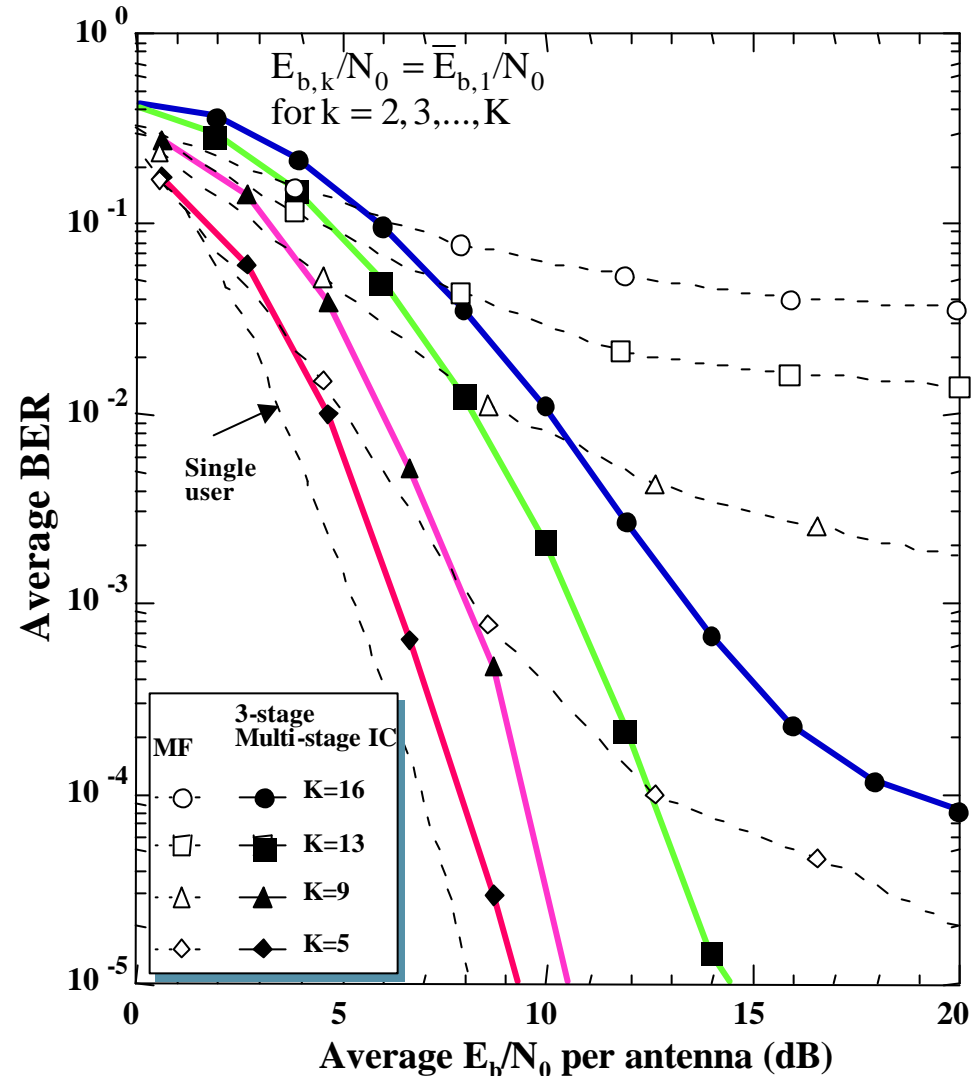
# Multi-stage IC Receiver Structure

- Interference subtraction is performed successively for different users in the order of decreasing power



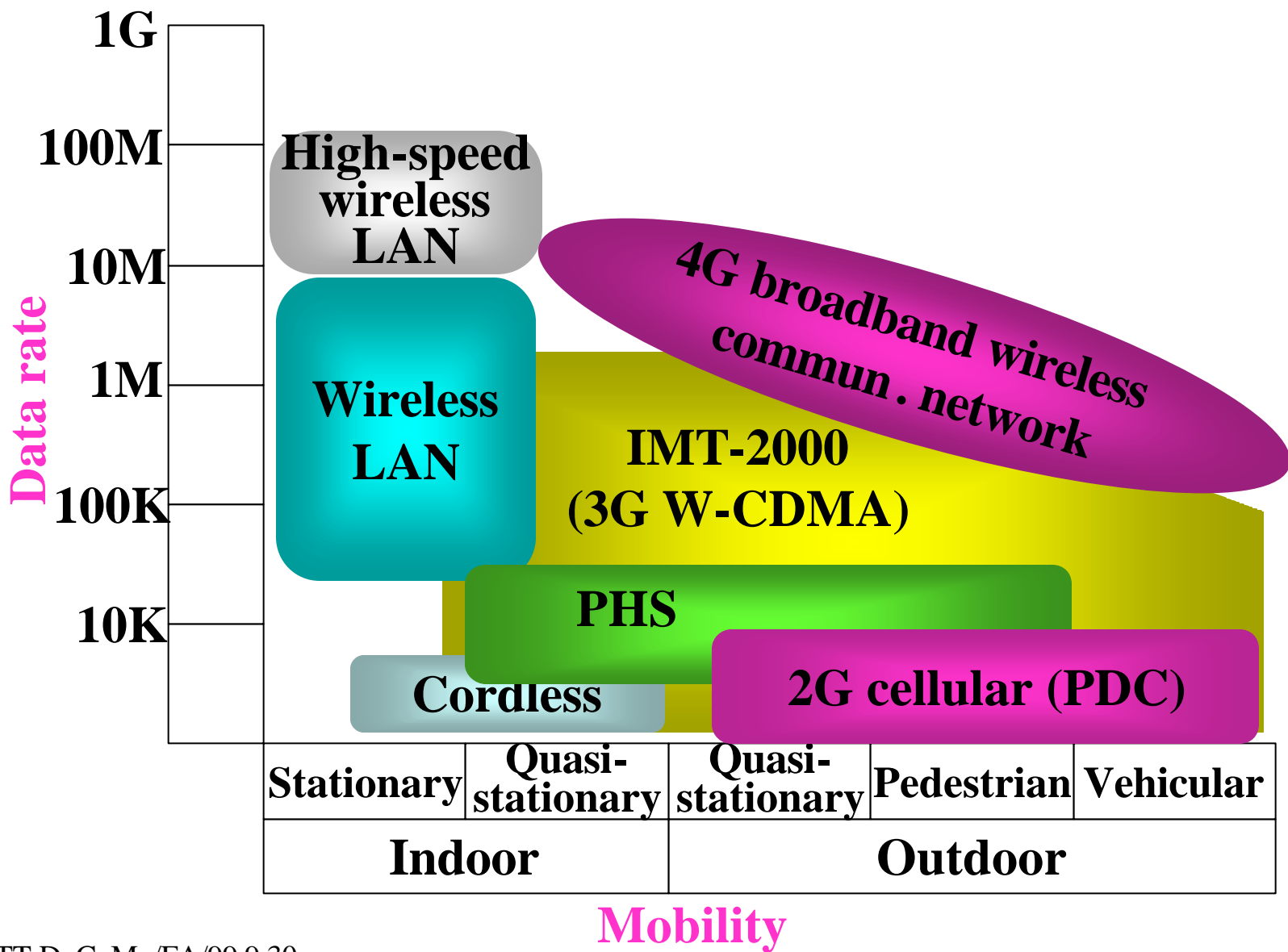
# Measured BER Performance with 3-stage IC (Laboratory Experiment)

- The BER performance improvement is almost saturated at 3-stage



1.024Mc/s, SF=16  
 2-path Rayleigh,  $f_D T_{\text{slot}}=0.05$  (80Hz)  
 Antenna diversity, Convolutional coding  
 No fast TPC

# Broadband Wireless Communications



# What is 4G System?

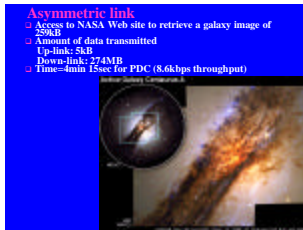
- A major objective is to provide mobile users broadband multimedia services, which will soon be in full force in fixed networks based on next generation Internet technology
- Information transferred over the Internet will become increasingly rich, more interactive. Information may contain high-quality still and moving images
- Other services may include
  - Various e-commerce transactions
  - Broadcasting services
  - Support of Intelligent Transportation Systems (ITS)

# 4G System Is A Broadband Wireless Packet System?

- **Broadband wireless multiple access optimized for IP transfer**
- ✓ **Broadband packet access with peak rate of more than 2Mbps in a vehicular environment and 10-20Mbps in stationary-to-pedestrian environments**
- ✓ **Flexible resource allocation between up- and down-link**
- **Wireless IP network**
- ✓ **Intelligent IP data routing algorithm with mobility handling**
- ✓ **Pico-cell with fast handoff algorithm**
- **Inter-operation with 3G**
- ✓ **Software radio technology**

# Technical Challenges

- ❑ **Broadband propagation channel produces severer frequency selective fading**
  - **Robust broadband data modulation scheme is necessary**
- ❑ **Significant difference between forward and reverse link rates**  
e.g. **WEB site access and down load of a 259kB image data indicates up/down link rate ratio of 1:55**



- ❑ **Which wireless access, TDMA, DS-CDMA, or OFDM?**
  - ✓ **It may be hybrid use of OFDM and DS-CDMA with TDD**

# Technical Challenges (cont'd)

## □ Power limitation

$$\text{Power} \propto f^{2.6} \times \text{Rate}$$

### - Example:

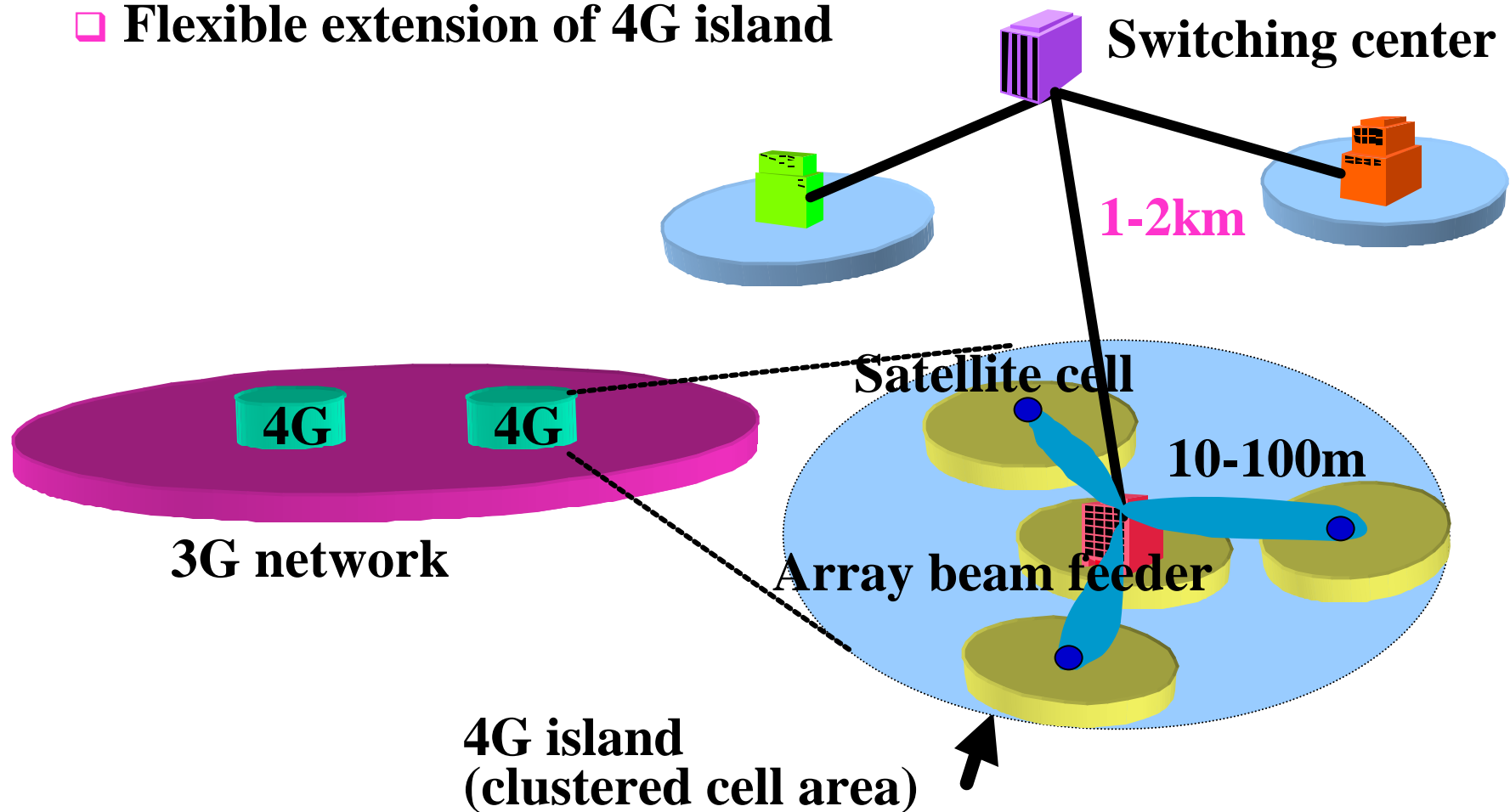
Transmit power with 64 kbps at 5GHz is **87** times larger than with 8kbps at 2GHz, or cell size must be reduced by about 3.7 times (**pico cell**)

## □ Power reduction and interference suppression techniques are important

- Space-time processing (adaptive antenna array and coding)
- Adaptive modulation
- Packet interference cancellation

# Concept of 4G System

- ❑ 4G island covers high multimedia traffic area
- ❑ 4G island inter-operates with 3G network
- ❑ Flexible extension of 4G island





# Conclusion

- ❑ **G3G CDMA system**
  - **Target year is 2001**
  - **Flexible offer of wideband multimedia services in addition to basic service (voice/fax/voice-band data)**
  - **Up to 2Mbps transfer rates**
  - **Larger capacity and wider coverage than any other 2nd generation systems (GSM, PDC, IS95, etc)**
- ❑ **G3G CDMA can be enhanced by advanced wireless techniques, i.e.**
  - **Adaptive antenna array transceiver**
  - **Interference canceling receiver**
- ❑ **4G system for rich multimedia communications services**
  - **Target year is around 2010**
  - **Broadband wireless packet access with peak rate of > 20Mbps**
  - **Significantly bandwidth/power efficient techniques necessary**
    - Space-time processing, packet interference cancellation**
  - **Inter-operation with 3G**
    - Software radio technology**

**We will continuously face  
very difficult but  
interesting technical  
challenges in the coming  
years!  
Thank you!**