Chapter 6

Multiple Access Techniques

By: Dr Musaddaq Mahir Abdul Zahra

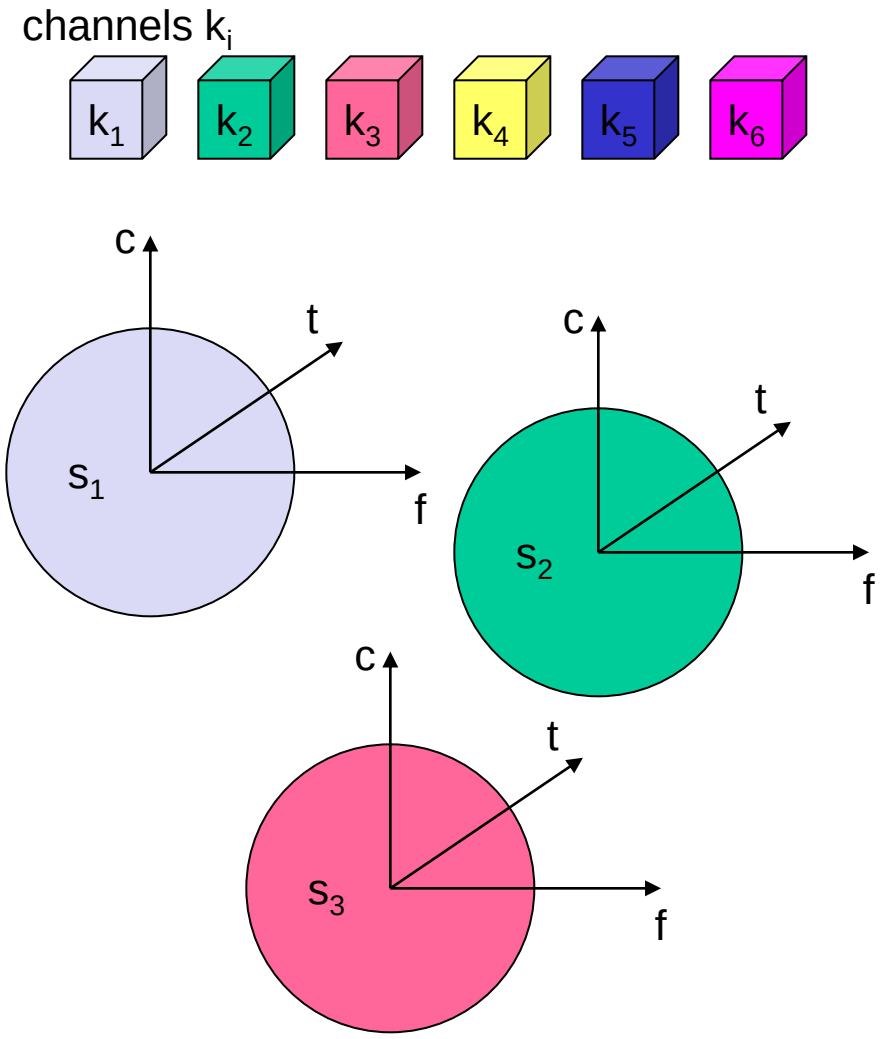
6.1 Multiplexing

Multiplexing in 4 dimensions

- space (s_i)
- time (t)
- frequency (f)
- code (c)

Goal: multiple use
of a shared medium

Important: guard spaces needed!



6.1.1 Frequency multiplex

Separation of the whole spectrum into smaller frequency bands

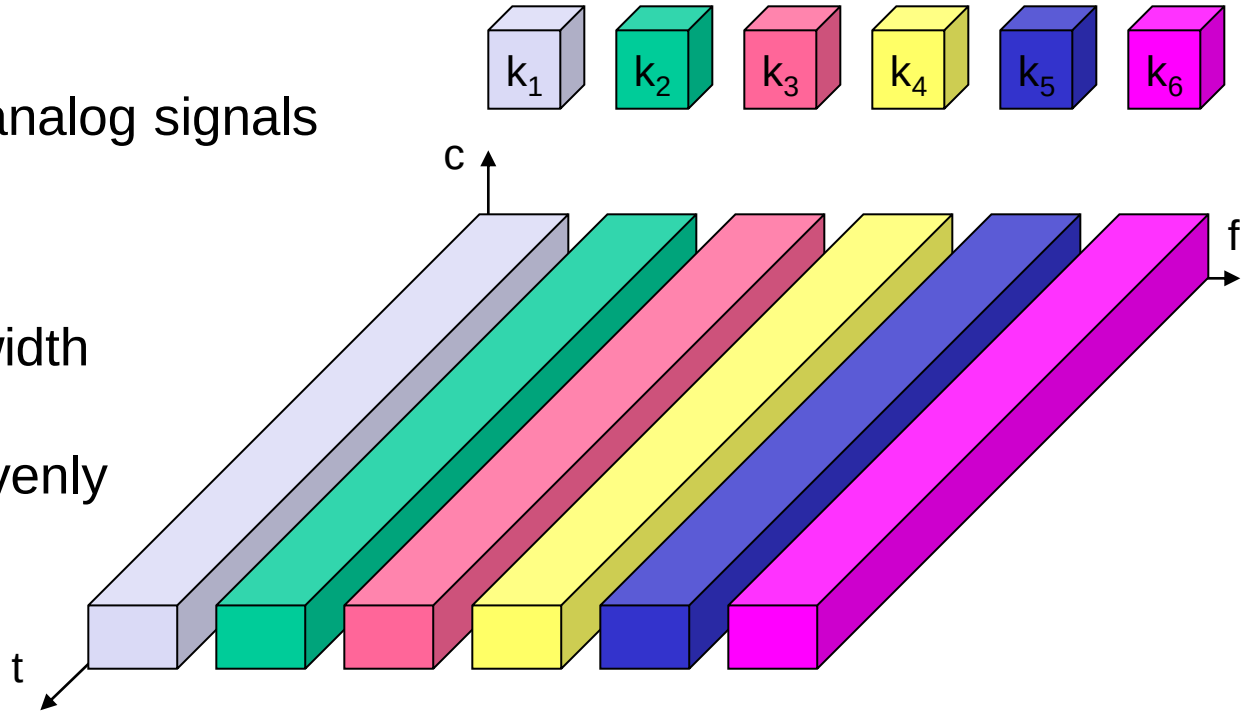
A channel gets a certain band of the spectrum for the whole time

Advantages:

- no dynamic coordination necessary
- works also for analog signals

Disadvantages:

- waste of bandwidth if the traffic is distributed unevenly
- inflexible
- guard spaces

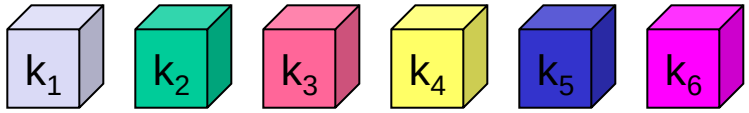


6.1.2 Time multiplex

A channel gets the whole spectrum for a certain amount of time

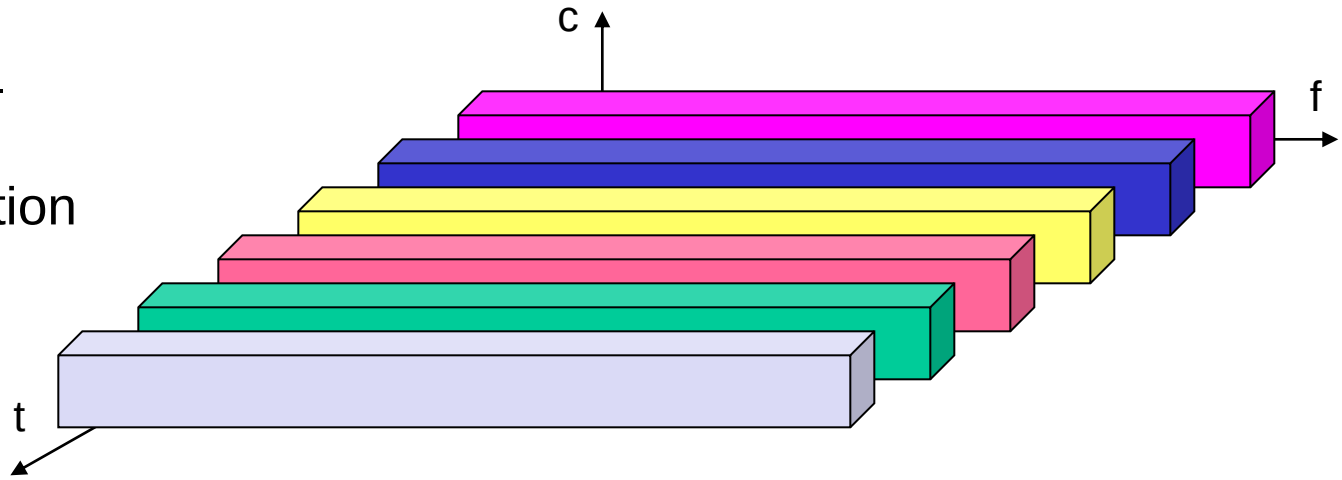
Advantages:

- only one carrier in the medium at any time
- throughput high even for many users



Disadvantages:

- precise synchronization necessary



6.1.3 Time and frequency multiplex

Combination of both methods

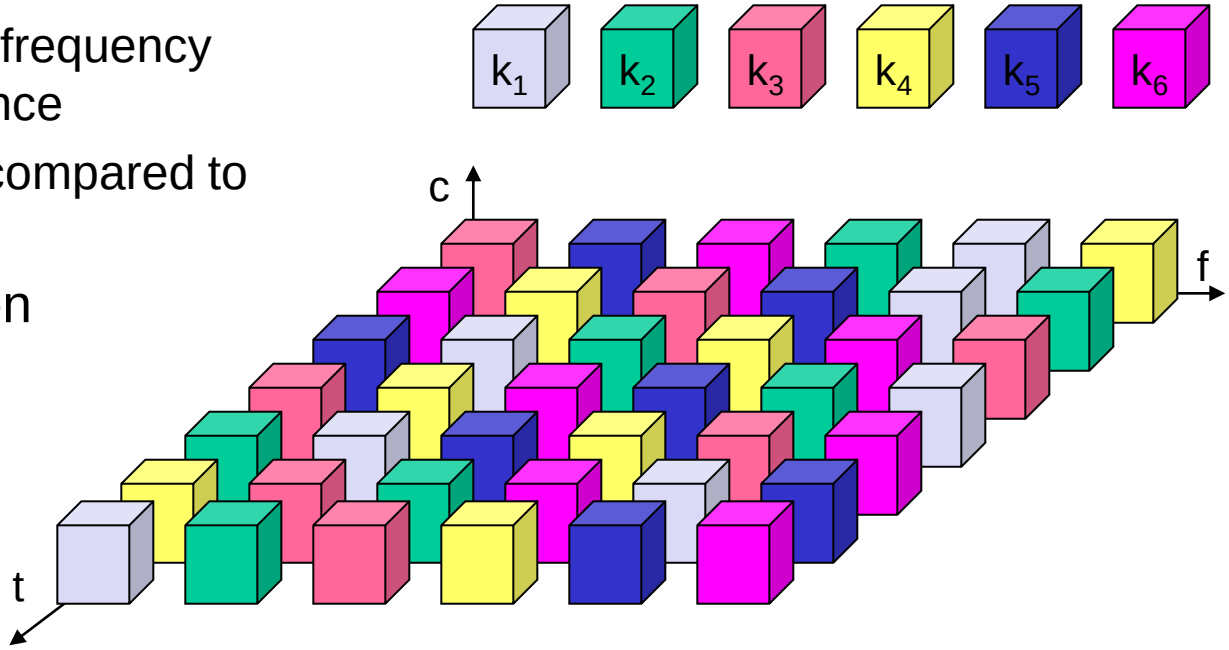
A channel gets a certain frequency band for a certain amount of time

Example: GSM

Advantages:

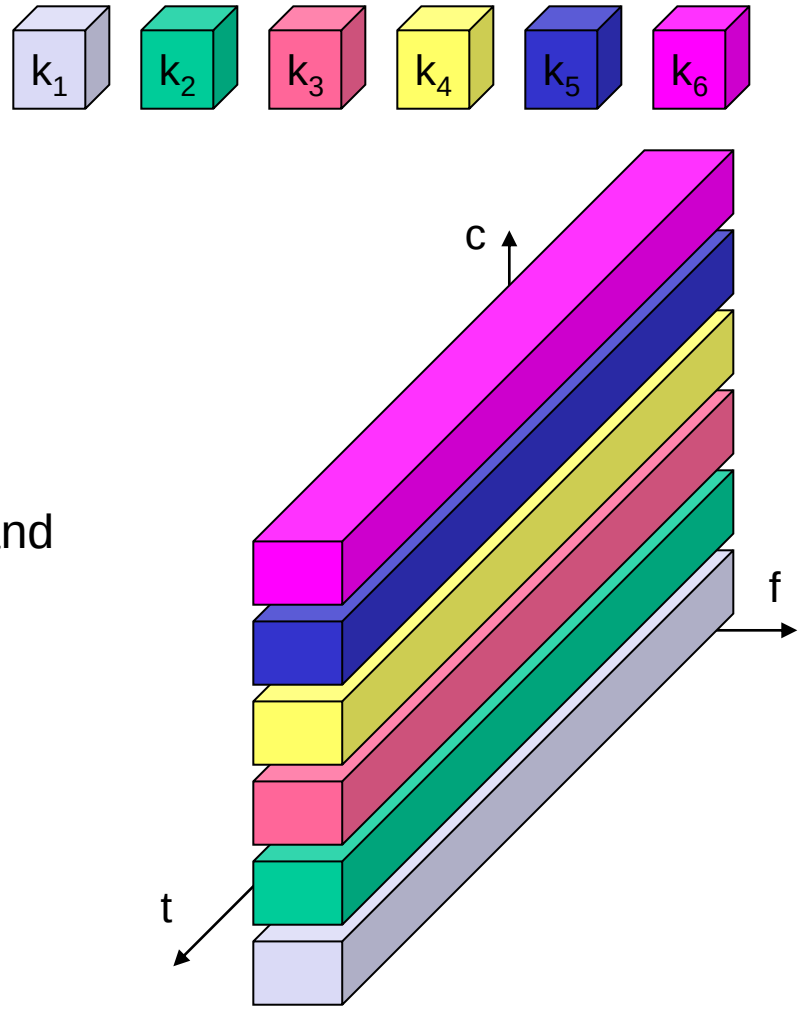
- better protection against tapping
- protection against frequency selective interference
- higher data rates compared to code multiplex

but: precise coordination required



6.1.4 Code multiplex

Each channel has a unique code



All channels use the same spectrum at the same time

Advantages:

- bandwidth efficient
- no coordination and synchronization necessary
- good protection against interference and tapping

Disadvantages:

- lower user data rates
- more complex signal regeneration

Implemented using spread spectrum technology

6.2 Multiple Division Techniques

To accommodate a number of users, many traffic channels need to be made available.

In principle, there are three basic ways to have many channels within an allocated bandwidth:

- Frequency Division Multiple Access (FDMA)
- Time Division Multiple Access (TDMA)
- Code Division Multiple Access (CDMA)

- System employs different carrier frequency – FDMA system.
- System uses distinct time – TDMA system.
- System uses different code – CDMA system.
- In wireless communications, it is necessary to utilize limited frequency bands at the same time, allowing multiple users(MSs) to share radio channel simultaneously.
- To provide simultaneous two-way communication (duplex communication) :
  - Frequency division duplexing (FDD)
  - Time Division Duplexing (TDD)

FDMA uses FDD, TDMA & CDMA uses TDD & FDD

6.3.1 QPSK modulation

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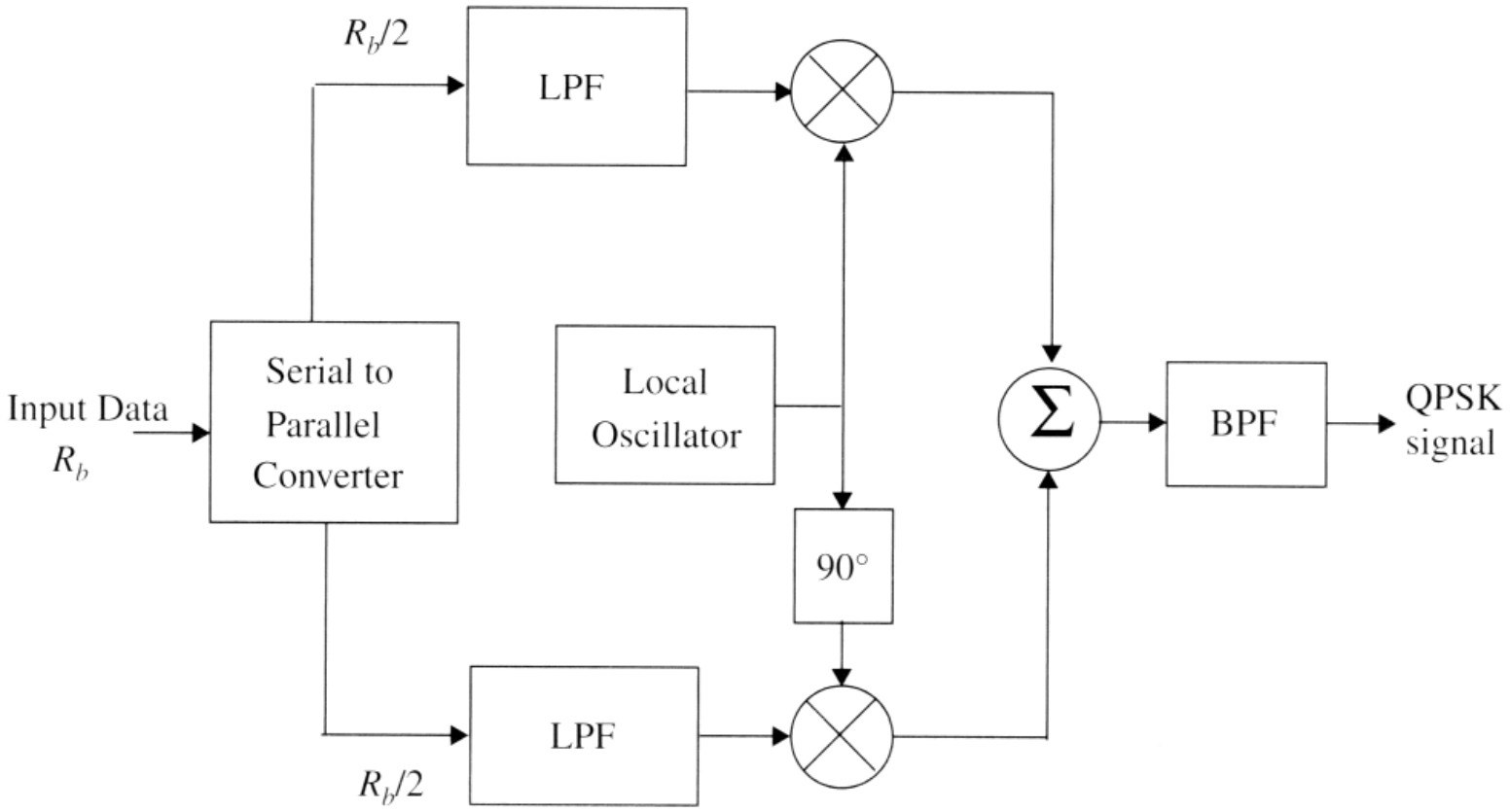

Fig. 7 Block diagram of a QPSK transmitter.

6.3.2 QPSK receiver

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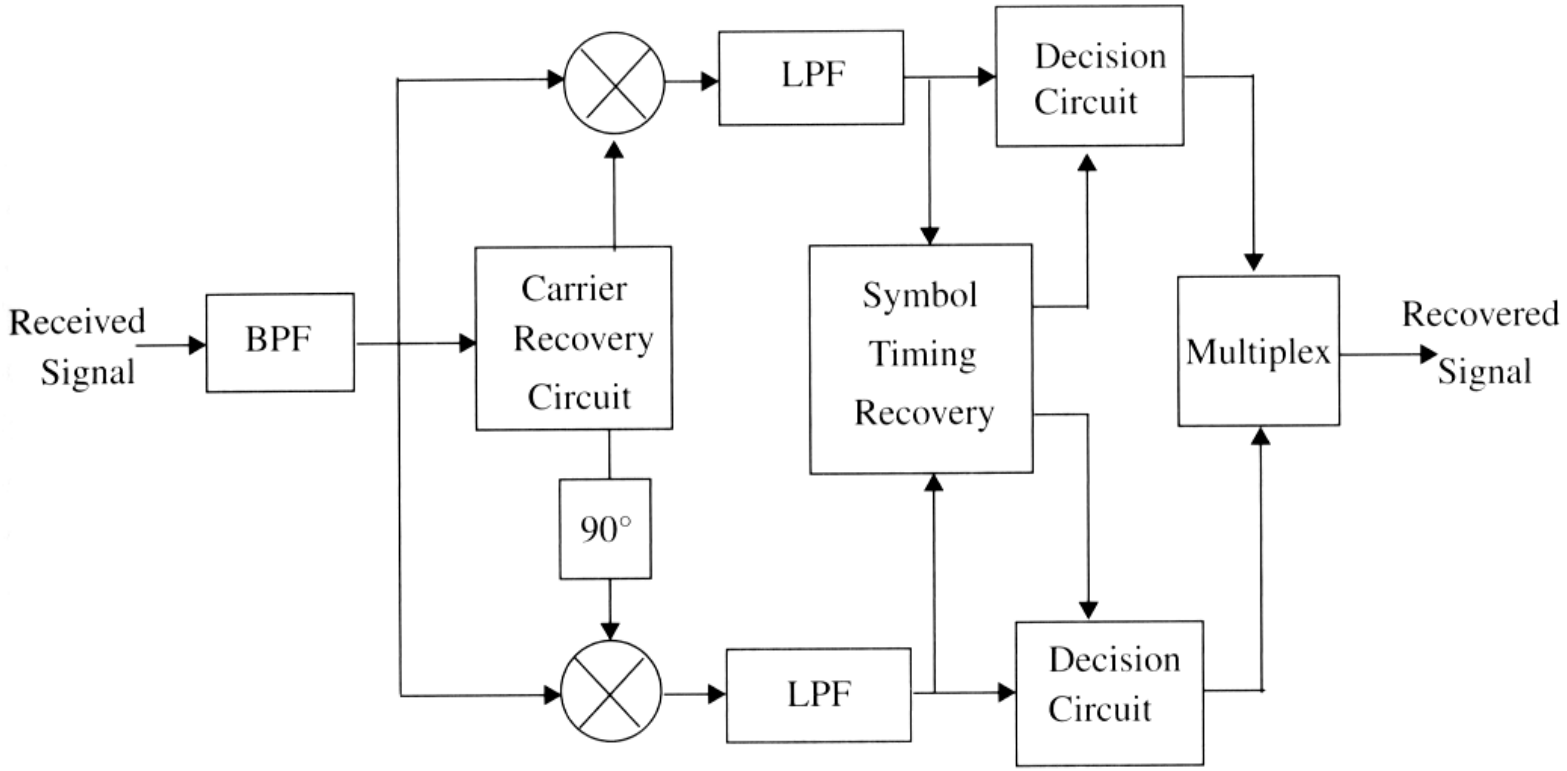

Fig. 8 Block diagram of a QPSK receiver.

6.3.3 MSK modulation

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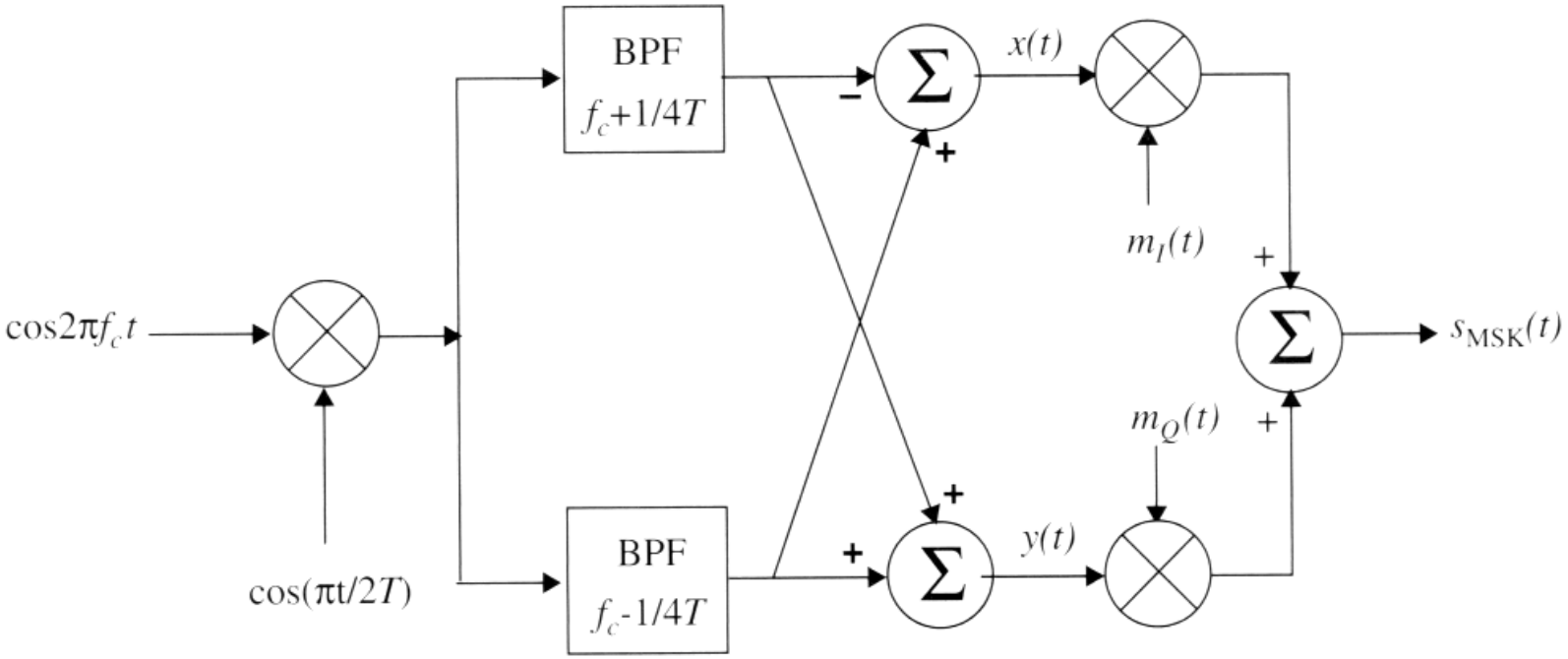


Fig. 9 Block diagram of an MSK transmitter. Note that $m_I(t)$ and $m_Q(t)$ are offset by T_b.

6.3.4 MSK reception

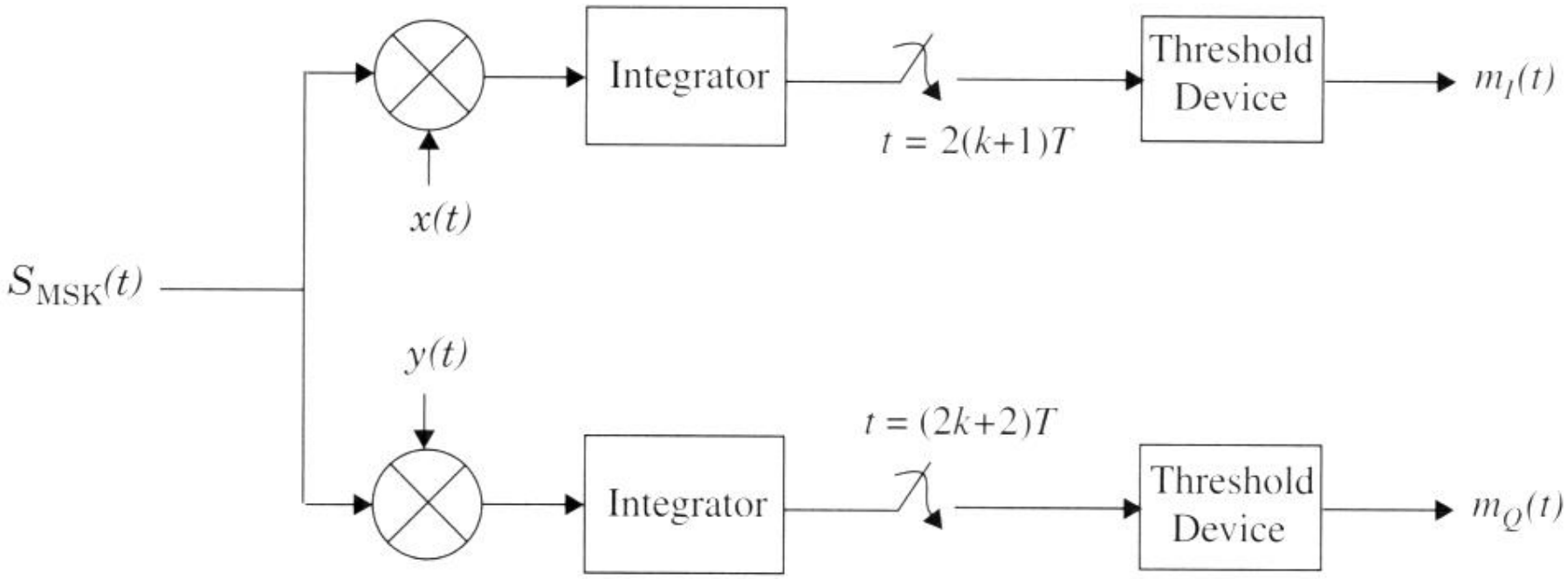
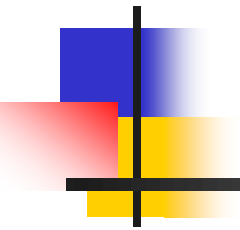


Fig. 10 Block diagram of an MSK receiver.



6.4 Wireless Systems

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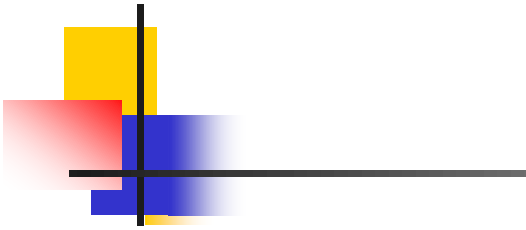
6.4.1 IS-95 Interfaces

- A Interface (BSC-MSC) .. This interface is between the BSC and the MSC. It supports both the control plane and user plane
- Abis Interface (BTS-BSC)—This is the interface between the BSC and BTS. This is internal interface and generally proprietary
- B Interface (MSC-VLR) This interface is defined by TIA IS-41
- C Interface (MSC-HLR) This interface uses IS-41 messaging as well
- D Interface (HLR-VLR) – HLR-VLR signaling is based on IS-41 as well. It sits on top of SS7
- E Interface (MSC-MSC)– Inter MSC signaling is defined in IS-41
- L interface (MSC-IWF) This interface allows the ability for circuit switched data in second generation networks
- Um Interface (BS-MS) – This is the air interface between the mobile and the network

6.4.2 Multiple Access

- Code-Division Multiple Access CDMA
  - unique digital codes are used to differentiate subscribers
  - codes are shared by both MS and BS
  - all users share the same range of radio spectrum

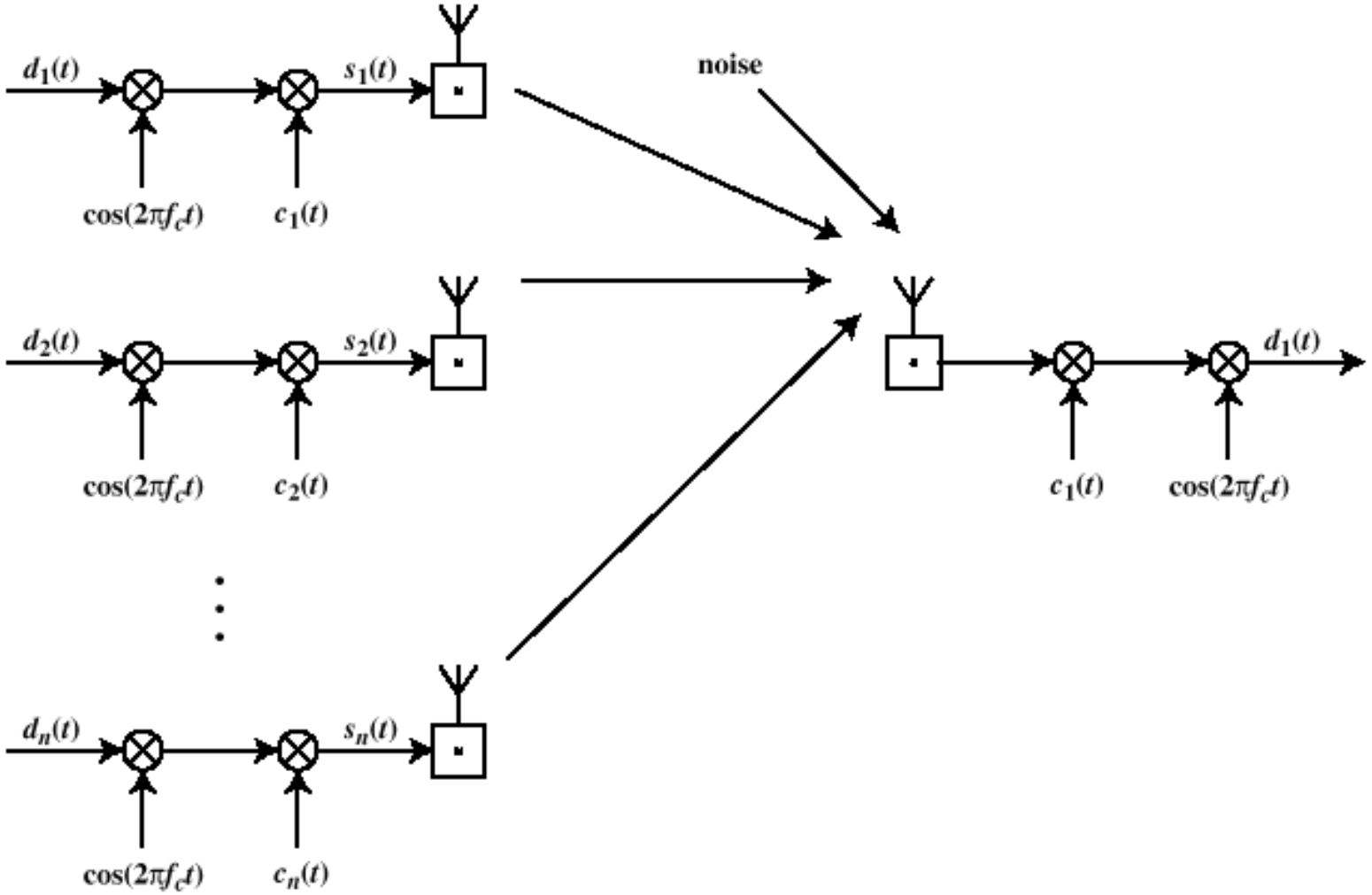
- Benefits of CDMA:
  1) Capacity increases: 4 to 5 times (GSM)
  2) Improved call quality
  3) Simplified system planning
  4) Enhanced privacy

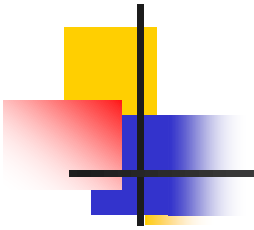


5) Improved coverage characteristics
6) Increased talk time for portables
7) Bandwidth on demand

- 6.4.3 Disadvantages
  - Receiver must be precisely synchronized with the transmitter to apply the decoding correctly
  - Receiver must know the code and must separate the channel with user data from the background noise composed of other signals and environmental noise

6.4.4 CDMA for DSSS

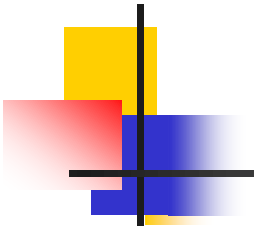




6.4.5 What is GPRS ?

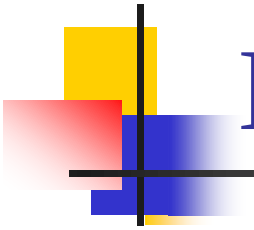
- General Packet Radio Service (GPRS) is a new bearer service for GSM that greatly improves and simplifies wireless access to packet data networks

- GPRS applies packet radio principal to transfer user data packets in an efficient way b/w MS & external packet data network



GPRS Mobile Stations:

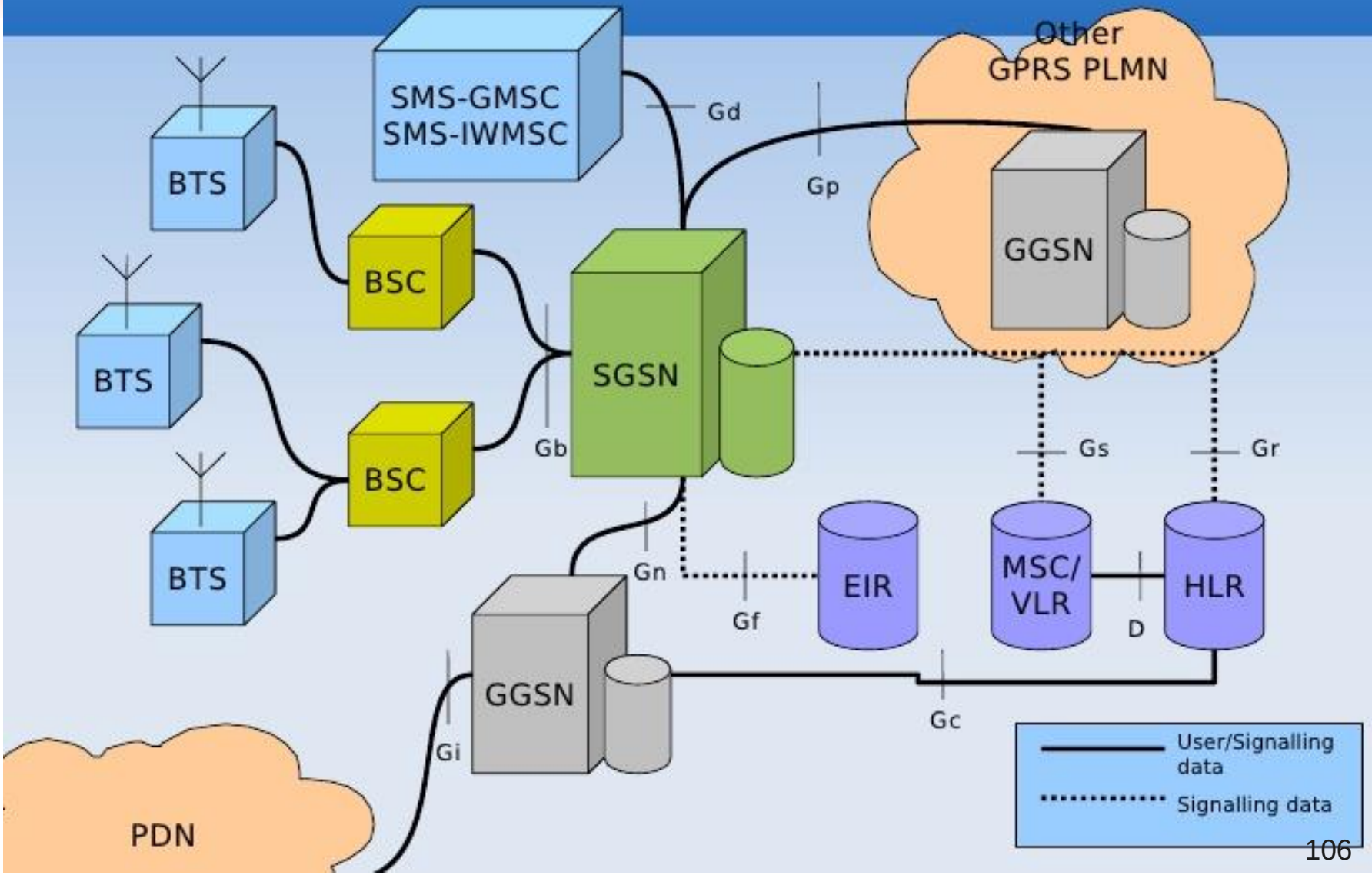
New Mobile Station are required to use GPRS services because existing GSM phones do not handle the enhanced air interface or packet data. A variety of MS can exist, including a high-speed version of current phones to support high-speed data access, a new PDA device with an embedded GSM phone, and PC cards for laptop computers. These mobile stations are backward compatible for making voice calls using GSM



Benefits of GPRS

- New Data Services
- High Speed (Data Rate 14.4 – 115 kbps)
- Efficient use of radio bandwith (Statistical Multiplexing)
- Circuit switching & Packet Switching can be used in parallel
- Constant connectivity

GPRS System Architecture



6.5 WiFi, Bluetooth and ZigBee

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6.5.1 Wireless Technology Differences

Standard	Family	Downlink (Mbps)	Uplink (Mbps)	Coverage
WiFi	802.11	11/54/150/300		100m
WiMAX	802.16e	144	35	10km
UMTS (3G) /HSPA (3.5G)	3GPP	14.4	5.76	30km
LTE (4G)	3GPP	360	80	30km

6.5.2 Diference between WiFi & WiMAX

WiFi vs. WiMAX

	IEEE 802.11	IEEE 802.16a
Max Speed	54Mbps (a&g)	10-100Mbps
Range	100m	40 km
Coverage	Indoor	Outdoor
Users	Hundred	Thousand
Service Level	None	Yes

6.5.3 Bluetooth vs. WiFi

	Bluetooth	Wifi
Specifications authority	Bluetooth SIG	IEEE, WECA
Year of development	1994	1991
Bandwidth	Low (800 Kbps)	High (11 Mbps)
Hardware requirement	Bluetooth adaptor on all the devices connecting with each other	Wireless adaptors on all the devices of the network, a wireless router and/or wireless access points
Cost	Low	High
Power Consumption	Low	High
Frequency	2.4 GHz	2.4 GHz
Security	It is less secure	It is more secure
Range	10 meters	100 meters
Primary Devices	Mobile phones, mouse, keyboards,office and industrial automation devices	Notebook computers, desktopcomputers, servers
Ease of Use	Fairly simple to use. Can be used to connect upto seven devices at a time. It is easy to switch between devices or find and connect to any device.	It is more complex and requires configuration of hardware and software.

6.5.4 Bluetooth vs. ZigBee

	Bluetooth (v1)	ZigBee
Protocol Stack	250 kb	< 32 kb (4kb)
Range	10 - 100 meters	30 - 100 meters
Link Rate	1 Mbps	250 kbps
Battery	rechargeable	non-rechargeable
Devices	8	2^16
Air Interface	FHSS	DSSS
Usage	frequently	infrequently
Network Join Time	long	short
Extendibility	no	yes
Security	PIN, 64 bit, 128 Bit	128 bit, AES