

# Mobile Communications (1)

## Class Overview

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# Wireless LAN

	802.11	802.11b	802.11a	802.11g	802.11n	802.11ac
year	1997	1999	1999	2003	2009	2014
frequency	2.4GHz	2.4GHz	5GHz	2.4GHz	2.4GHz & 5GHz	5GHz
bitrate	1 – 2 Mbps	1 – 11 Mbps	6 – 54 Mbps	1 – 54 Mbps	1 – 600 Mbps	~ 6.77 Gbps
multiple access, and modulation	DSSS, FH, IrDA	DSSS, CCK	OFDM	DSSS, CCK, OFDM	OFDM, MIMO, channel bonding	OFDM, MIMO, channel bonding

→ 802/11ax

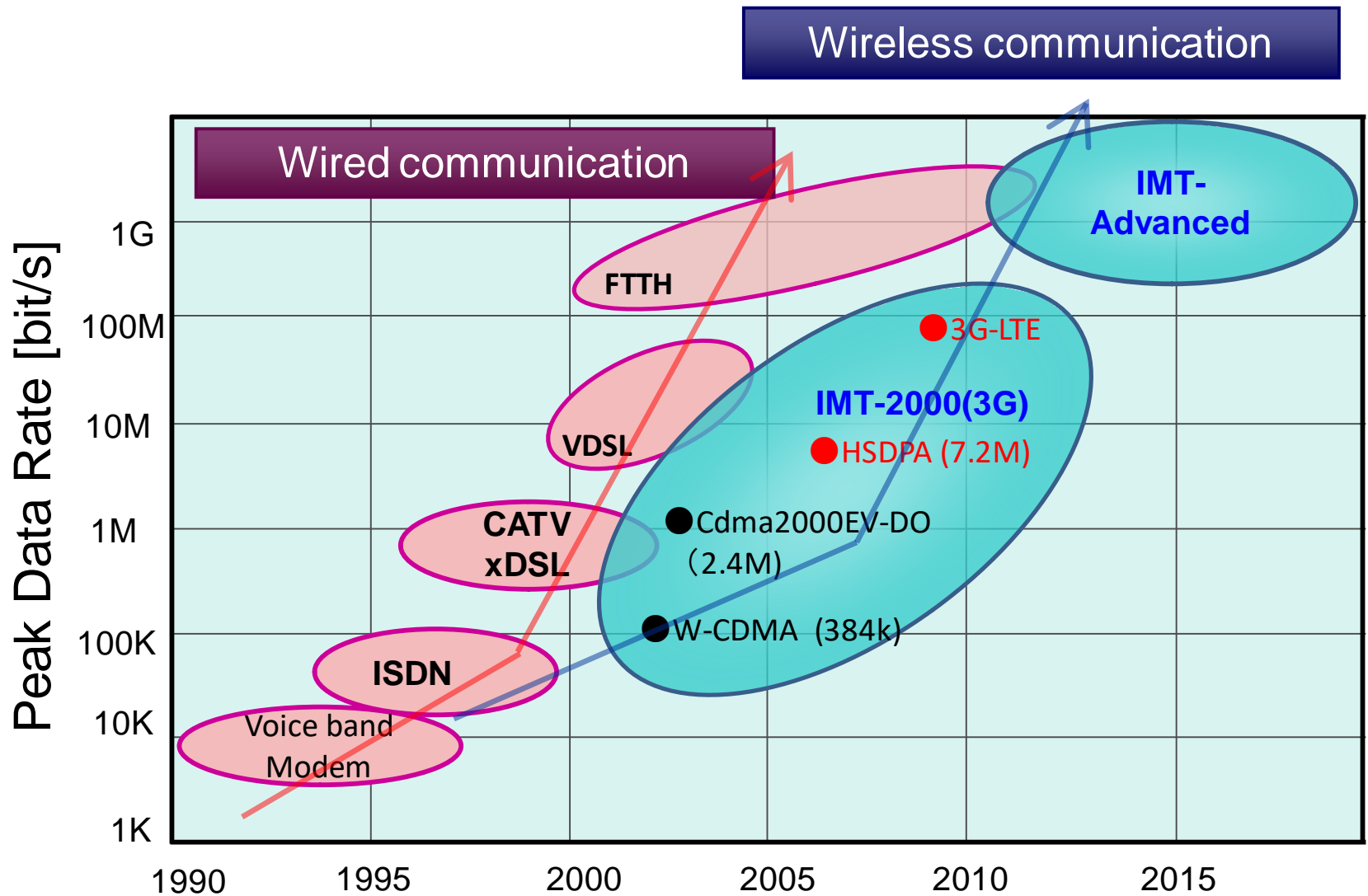
# Wireless PAN/BAN

	802.15.1	802.15.3a	802.15.4a	802.15.4	802.15.6
<b>name</b>	Bluetooth	UWB	UWB	ZigBee	BAN
<b>year</b>	1999	--	2007	2003	2012?
<b>frequency</b>	2.4GHz	3.1 – 10.6GHz	2.4GHz	2.4GHz 868MHz 915MHz	400MHz 2.4GHz
<b>bitrate</b>	720kbps- 24Mbps	480Mbps	1Mbps	20-250 kbps	~10Mbps
<b>multiple access, and modulation</b>	FH GFSK	OFDM or DSSS	DSSS BPSK	DSSS BPSK/QPS K	?
<b>distance</b>	1-100m	4-10m	10m	10-75m	3m
<b>power</b>	1-100mW	< 100mW	1mW	< 60mW	< 1mW?

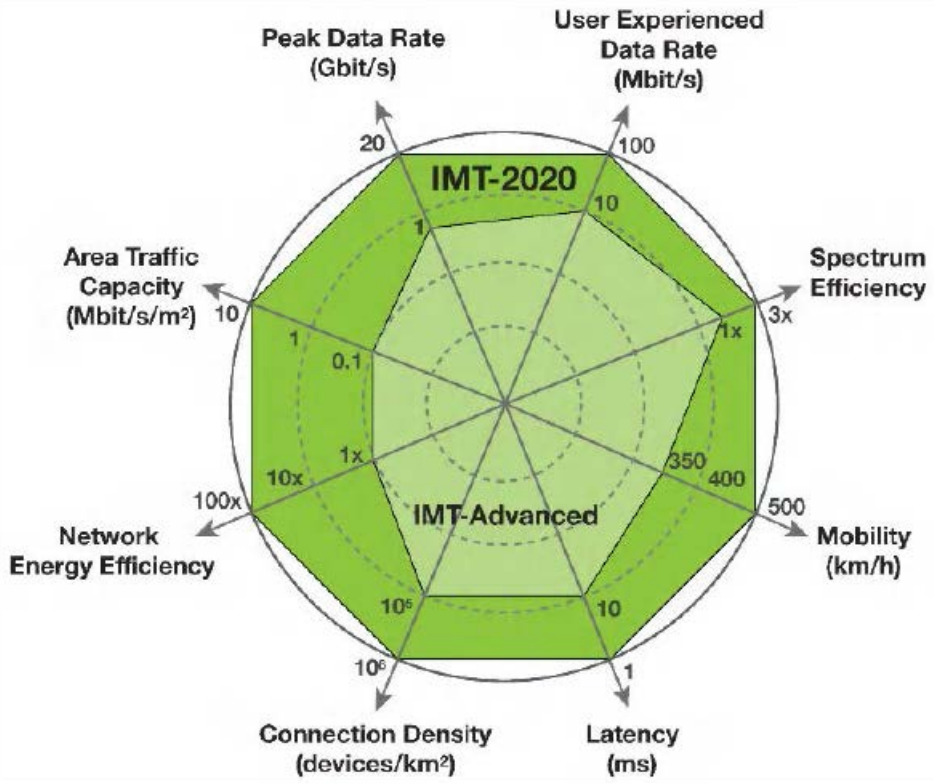
# Cellular

generation	name	frequency	multiple access	modulation	bitrate (downlink)	speech codec
2G	PDC	800MHz / 1.5GHz	FDD-TDMA	$\pi/4$ -DQPSK	9.6 - 28.8 kbps	ACELP, PSI-CELP
	cdmaOne	800MHz	FDD-CDMA	$\pi/4$ -DQPSK	14.4 - 64 kbps	EVRC
	GSM	--	FDD-TDMA	GMSK	9.6 - 171.2 kbps	ACELP
	PHS	1.9GHz	TDD-TDMA	$\pi/4$ -DQPSK	32-256 kbps	ADPCM
3G (IMT-2000)	W-CDMA	800MHz / 1.7GHz / 2GHz	FDD-CDMA	$\pi/4$ -DQPSK	384kbps	AMR
	CDMA2000	800MHz / 2GHz	FDD-CDMA	$\pi/4$ -DQPSK	144kbps	EVRC
3.5G	HSPA	1.7GHz	(W-CDMA)	QPSK~16QAM	1.22 -14 Mbps	--
	EV-DO	800MHz / 2GHz	(CDMA2000)	QPSK~16QAM	2.4 -3.1 Mbps	--
3.9G (Super3G)	LTE	800MHz / 1.5GHz / 2GHz	OFDMA/SD-FDMA/MIMO	QPSK~64QAM	100 - 326.4 Mbps	--
4G (IMT-Advanced)	LTE-Advanced	3.4~3.6GHz	OFDMA/MIMO/CoMP	QPSK~64QAM	~1Gbps	--
5G (IMT-2020)		3.5-4.2GHz, 28GHz	Massive MIMO	QPSK~256QAM ?	~20Gbps ?	

# IMT-Advanced (4G/LTE)



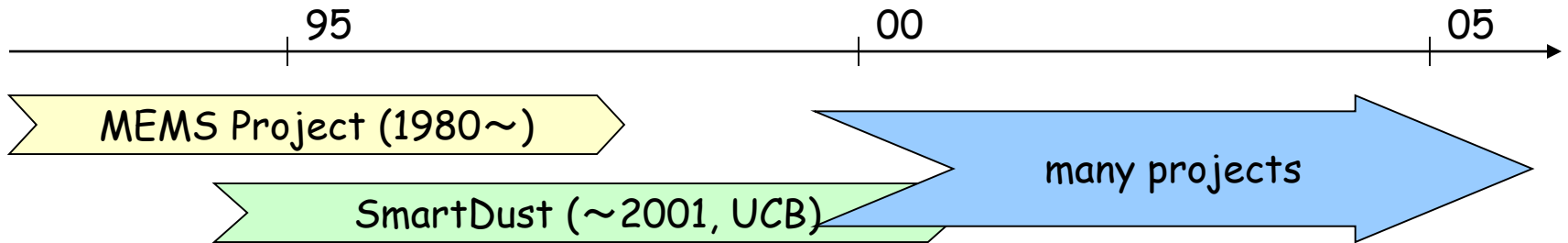
# IMT-2020 (5G)



	IEEE802.11
Peak Rate	<7Gbps
User data rate	Not guaranteed
Spectrum efficiency	Not guaranteed (contention, interference)
Mobility	Pedestrian
Latency	Not guaranteed (network discovery, contention, interference)
Connection density	High (conference rooms, stadia)
Network Energy Efficiency	Not guaranteed (network discovery, contention, interference)
Area Traffic Capacity	High (limited by backhaul)

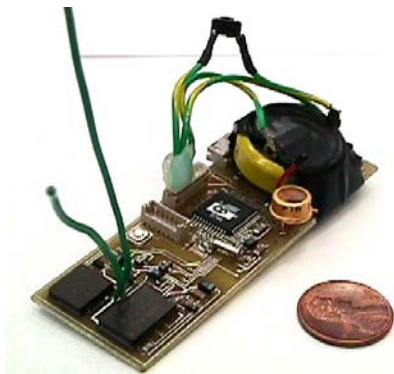
# Sensor Networks

- history



**Sensor(s) + MPU(s) + Networking → On-board → On-chip**

RF Mote



- Prototype      ▲ COTS Dust, Tiny OS
- Companies      ▲ Crossbow, Dust, Ember, Senticast, ...
- Conferences      ▲ IEEE Sensors, ACM SenSys, ...
- Standards      ▲ IEEE 802.15.4 (ZigBee)

a slide five years ago

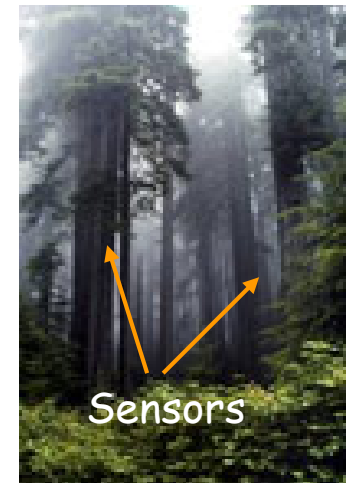
# Sensor Networks

- (1) factory
- (2) maintenance
- (3) military, national security
- (4) automation
- (5) environment monitoring
- (6) ubiquitous

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(7) smart phone

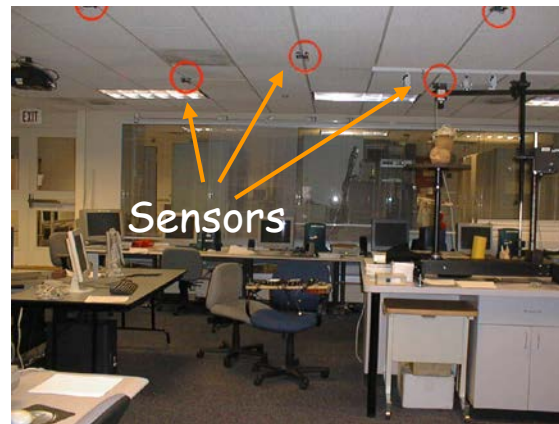
monitoring (UCB)



tracking (UCB)



smart room (MIT)



robot (USC)





# Smart Phone



- Communication
  - 3G/LTE, WiFi, Bluetooth, WiMAX, ...
- Audio and Visual
  - microphone, speaker, camera, display, ...
- Sensors
  - accelerometer, gyroscope, magnetic, proximity, light, temperature, ...

# Android APIs

## android.hardware.Sensor

### Summary

Constants		
int	<a href="#">TYPE_ACCELEROMETER</a>	A constant describing an accelerometer sensor type.
int	<a href="#">TYPE_ALL</a>	A constant describing all sensor types.
int	<a href="#">TYPE_AMBIENT_TEMPERATURE</a>	A constant describing an ambient temperature sensor type.
int	<a href="#">TYPE_GRAVITY</a>	A constant describing a gravity sensor type.
int	<a href="#">TYPE_GYROSCOPE</a>	A constant describing a gyroscope sensor type.
int	<a href="#">TYPE_LIGHT</a>	A constant describing a light sensor type.
int	<a href="#">TYPE_LINEAR_ACCELERATION</a>	A constant describing a linear acceleration sensor type.
int	<a href="#">TYPE_MAGNETIC_FIELD</a>	A constant describing a magnetic field sensor type.
int	<a href="#">TYPE_ORIENTATION</a>	<i>This constant was deprecated in API level 8. use <a href="#">SensorManager.getOrientation()</a> instead.</i>
int	<a href="#">TYPE_PRESSURE</a>	A constant describing a pressure sensor type.
int	<a href="#">TYPE_PROXIMITY</a>	A constant describing a proximity sensor type.
int	<a href="#">TYPE_RELATIVE_HUMIDITY</a>	A constant describing a relative humidity sensor type.
int	<a href="#">TYPE_ROTATION_VECTOR</a>	A constant describing a rotation vector sensor type.
int	<a href="#">TYPE_TEMPERATURE</a>	<i>This constant was deprecated in API level 14. use <a href="#">Sensor.TYPE_AMBIENT_TEMPERATURE</a> instead.</i>

# This Year's Schedule

(tentative)

- 4/06 Class overview
- 4/13 Radio Communication Basics (1)
- 4/20 Self Study (1)
- 4/27 Radio Communication Basics (2)
- 5/11 Wireless LAN Standards (1)
- 5/18 Wireless LAN Standards (2)
- 5/25 Implementing Wireless LANs
- 6/01 Wireless LAN Security (1)
- 6/08 Wireless LAN Security (2)
- 6/15 Wireless PAN Standards
- 6/22 Wireless MAN Standards
- 6/29 Leading Edge Wireless Networking Technologies
- 7/06 tbd
- 7/13 Examination (in class room)
- 7/21 (Self-study on CourseN@vi)

Self-study on CourseN@vi,  
once or twice