



Course Objectives:

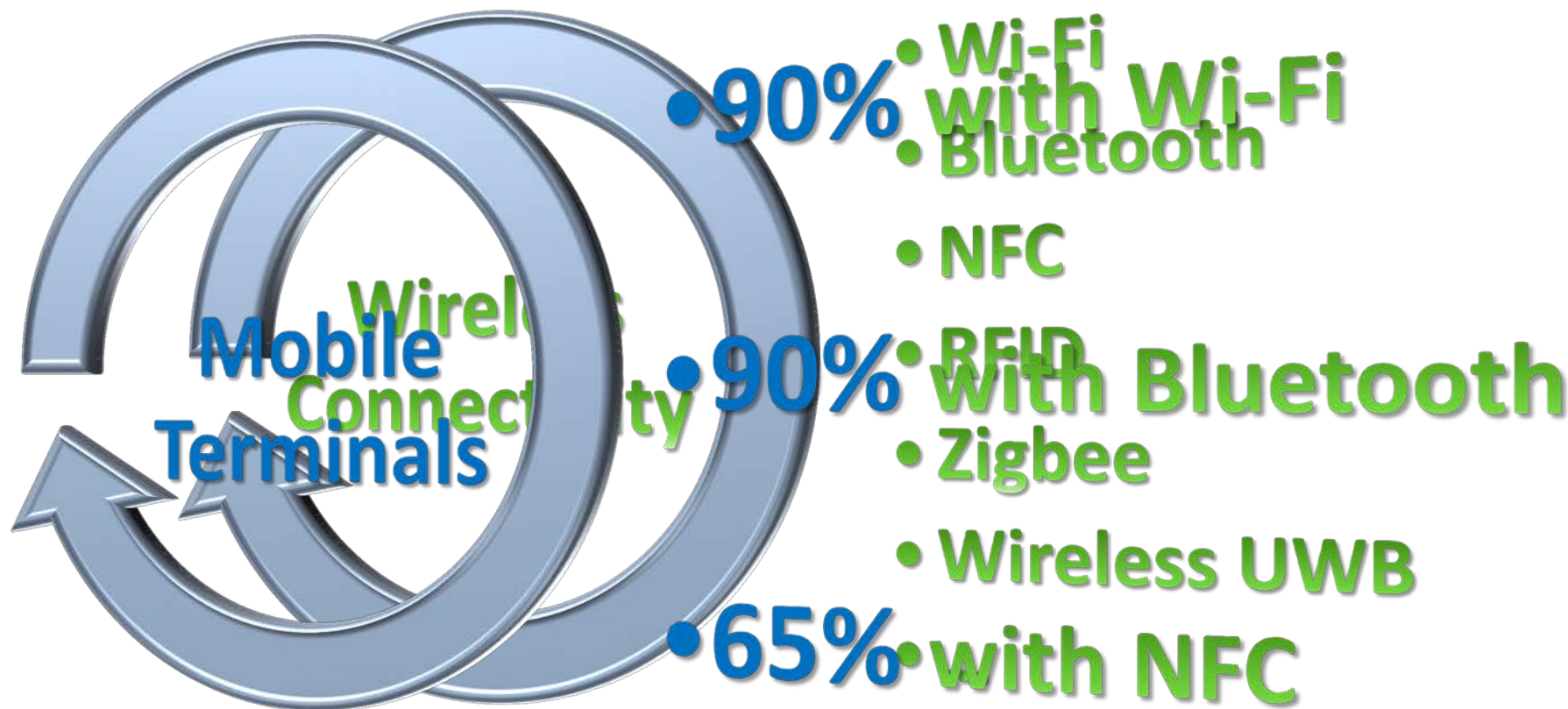
Bring an introduction of Wireless connectivity test of mobile terminals, including Wi-Fi, Bluetooth and NFC. Focusing on standard system, test specification and test tools for the testing.



Agenda:

- Why Include Wireless Connectivity
- Regulatory Test of Wireless Connectivity
- Wi-Fi Standard, Technology and Testing
- Bluetooth Standard, Technology and Testing
- NFC Standard Technology and Testing

Why Include Wireless Connectivity?



Fundamental Information



	Wi-Fi	Bluetooth	NFC
Standardization	IEEE	Bluetooth SIG	ISO/IEC
Test Specification	Wi-Fi Alliance	Bluetooth SIG	NFC Forum
Range	100m	10m	< 0.2m
Network Type	WLAN	WPAN	WTAN
Network Type	PTMP, MESH	PTMP, Scattered	P2P
Frequency	2.4G/5GHz	2.4G	13.56 MHz
Bit Rate	7Gbps	3 Mbps	424 Kbs
Set-up time	10 s	< 5 s	< 0.1 s

A List of Test Scope



Regulatory Test

RF Conformance

**Protocol
Conformance**

Interoperability

Agenda:

- Why Include Wireless Connectivity
- Regulatory Test of Wireless Connectivity
 - FCC Regulation
 - CE Regulation
- Wi-Fi Standard, Technology and Testing
- Bluetooth Standard, Technology and Testing
- NFC Standard Technology and Testing

FCC RF Regulation Requirements



■ Wi-Fi & Bluetooth

◆ RF FCC CFR 47, Part 15 Subpart C

- Section 15.205 Restricted bands of operation;
- Section 15.209 Radiated emission limits, general requirements
- Section 15.247 Operation within the bands 902–928MHz, 2400–2483.5 MHz, and 5725–5850 MHz

■ NFC

◆ RF FCC CFR 47, Part 15 Subpart C

● Subpart C

- Section 15.207 Conducted limits
- Section 15.209 Radiated emission limits, general requirements
- Section 15.215 Additional provisions to the general radiated emission limitations
- Section 15.225 Operation within the band 13.110-14.010 MHz

FCC RF Requirements



2.4GHz Wi-Fi Device

No.	Test Case
1	Peak Output Power-Conducted
2	Band Edges Compliance
3	Occupied 6dB Bandwidth
4	Conducted Emission
5	Radiated Emission
6	Peak Power Spectrum Density
7	AC Powerline Conducted Emission

Bluetooth Device

No.	Test Case
1	Peak Output Power-Conducted
2	Band Edges Compliance
3	20dB Bandwidth
4	Conducted Emission
5	Time of Occupancy (Dwell Time)
6	Carrier Frequency Separation
7	Number of hopping channels

FCC RF Requirements –5GHz Wi-Fi Device



No.	Test Case	Standard Clause
1	Maximum Output Power	15.407
2	Power Spectral Density	15.407
3	Occupied 26dB Bandwidth	15.403
4	Occupied 6dB Bandwidth	15.407
5	Band edge compliance	15.407
6	Transmitter spurious emissions radiated	15.407
7	Spurious emissions radiated	15.407
8	Spurious emissions conducted	15.407
9	Peak Excursion	15.407

FCC RF DFS Requirements

– 5GHz Device



Device work on 5250MHz-5350MHz and 5470MHz-5725MHz

- **Channel Availability Check Time** > 60 s
- **Channel Move Time** < 10 s
- **Channel Closing Transmission Time** < 60 ms
- **Non-Occupancy Period** > 30 minutes

No.	Test Case	Master	Client without radar detection	Client with radar detection
1	Channel Availability Check	√	×	×
2	DFS Detection Threshold	√	×	√
3	Non-Occupancy Period	√	×	√
4	Uniform Spreading	√	×	×
5	U-NII Detection Bandwidth	√	×	√
6	In service Monitoring	√	√	√

FCC RF Requirements –NFC Device



No.	Test Case	Standard Clause
1	Electric Field Strength of Fundamental Emissions	15.225(a)
2	Electric Field Strength of Outside the Allocated Bands	15.225(b) 15.225(c)
3	Electric Field Radiated Emissions	15.209 15.225(d)
4	Frequency Tolerance	15.225(e)
5	20dB Bandwidth	15.215(c)
6	Conducted Emissions	15.207

CE Regulation Requirements



■ Wi-Fi & Bluetooth

◆ RF

- EN 300328
- EN 301893

◆ EMC

- EN 301489-1(General)
- EN 301489-17(Bluetooth/WIFI)

◆ SAR (Wi-Fi Only)

- EN 50360:2001/EN62311:2008
- EN 62209-1:2006/EN 62209-2:2010

■ NFC

◆ RF

- ETSI EN 302 291

◆ EMC

- EN 301489-1(General)
- EN 301489-3(SRD)

Agenda:



- Why Include Wireless Connectivity
- Regulatory Test of Wireless Connectivity
- **WLAN Standard, Technology and Testing**
- Bluetooth Standard, Technology and Testing
- NFC Standard, Technology and Testing

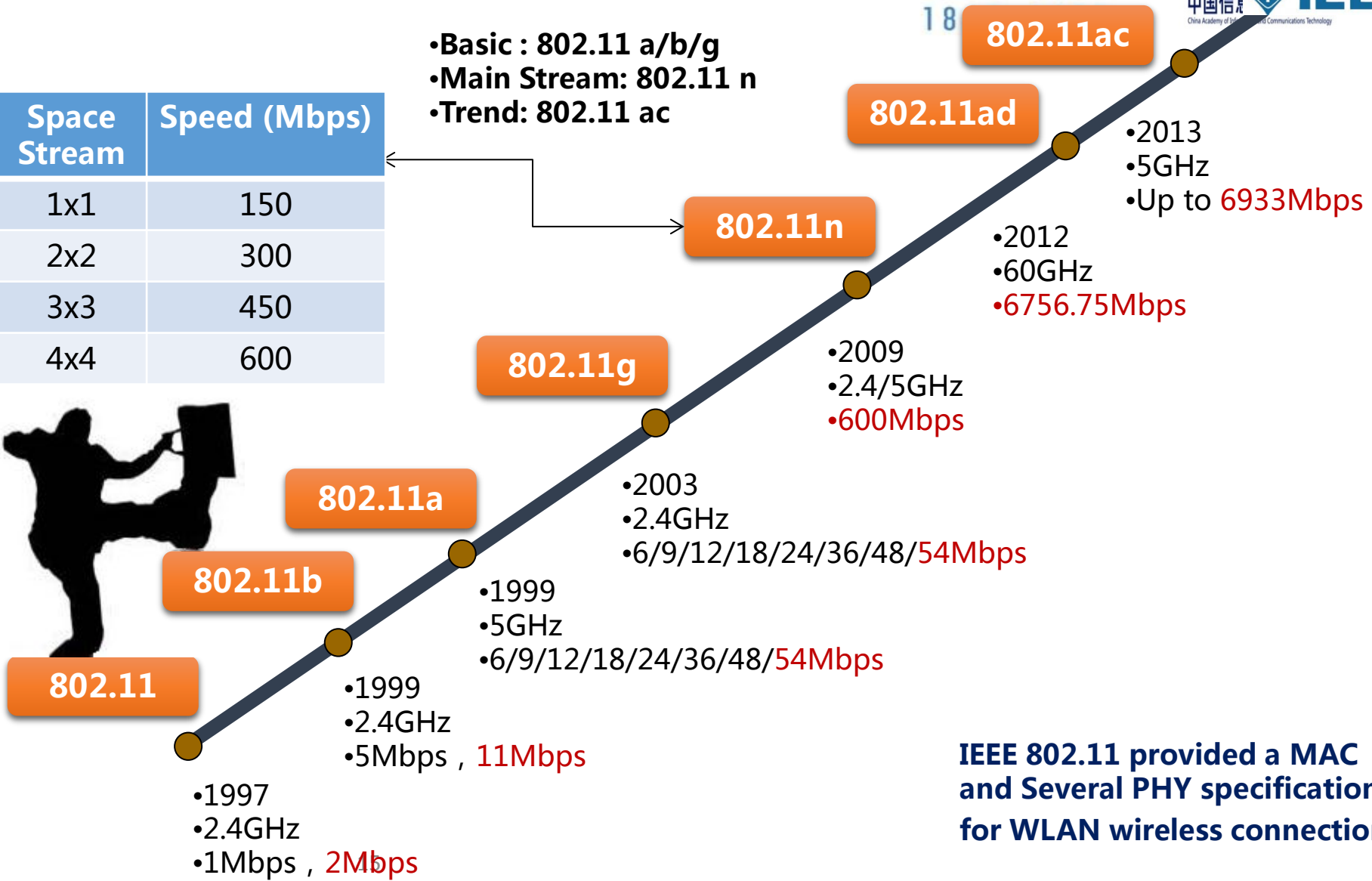
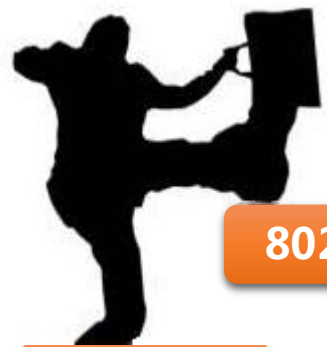


WLAN Standard System-IEEE 802.11



Space Stream	Speed (Mbps)
1x1	150
2x2	300
3x3	450
4x4	600

- Basic : 802.11 a/b/g
- Main Stream: 802.11 n
- Trend: 802.11 ac



IEEE 802.11 provided a MAC and Several PHY specifications for WLAN wireless connection.

Wi-Fi Alliance



**Global non-profit
industry association**

**600+ Member
Companies**

***Test Specification
Developer***

**18,000+ Wi-Fi
Certified**

**20+ Technical
Working Group**

Wi-Fi Test-General



Physical Connection

802.11abgn **fundamental**

802.11ac

Direct

Security

WPA2 **fundamental**

PMF

Network & Access

Passpoint

WPS

IBSS

Ensure the Interoperability and Compatibility of Wi-Fi Products

RF Coexistence

CWG

Application&Service

Miracast

Voice Personal

Voice Enterprise

Application optimize

WMM &WMM-PS

TDLS

WMM-AC

Wi-Fi Test -Fundamental

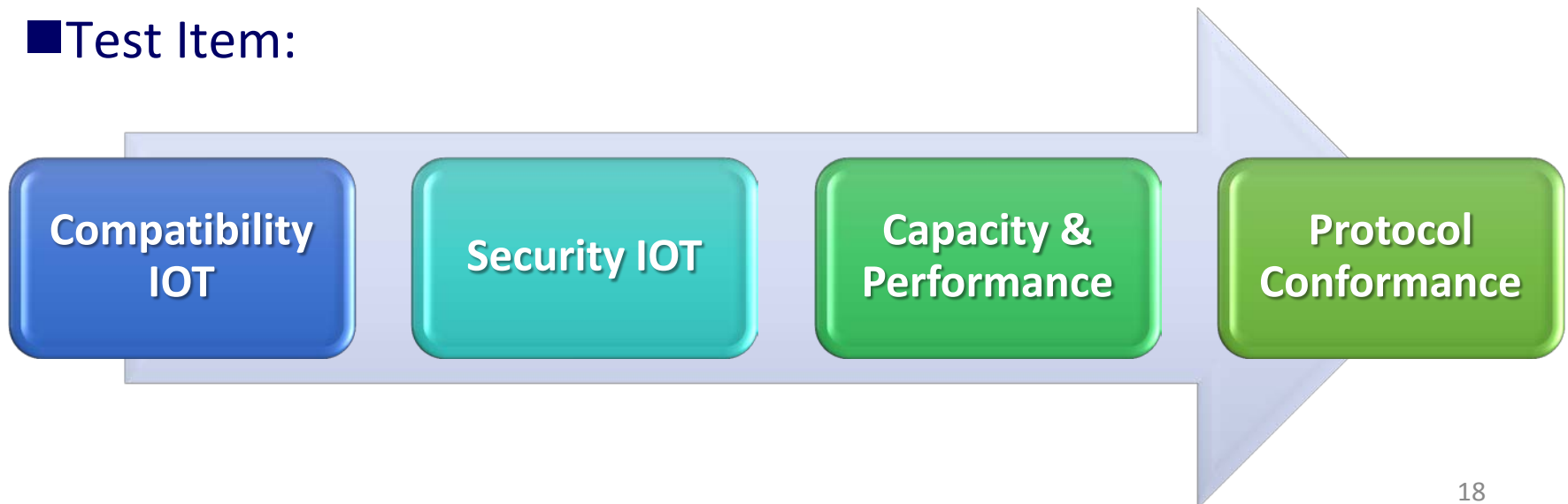


■Objective: verify Physical connection feature of Wi-Fi

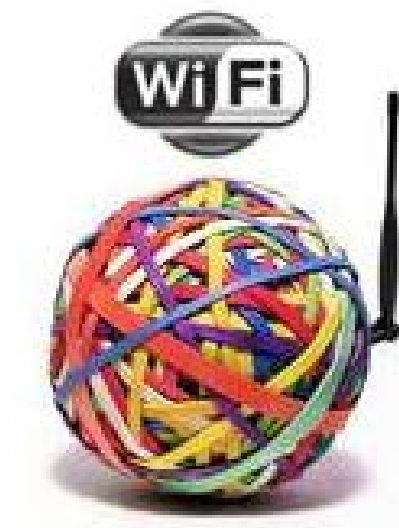
■Test Specification:

- 802.11n Products - 802.11abgn Interoperability Test
- Other Products - 802.11abg WPA2 Interoperability Test

■Test Item:



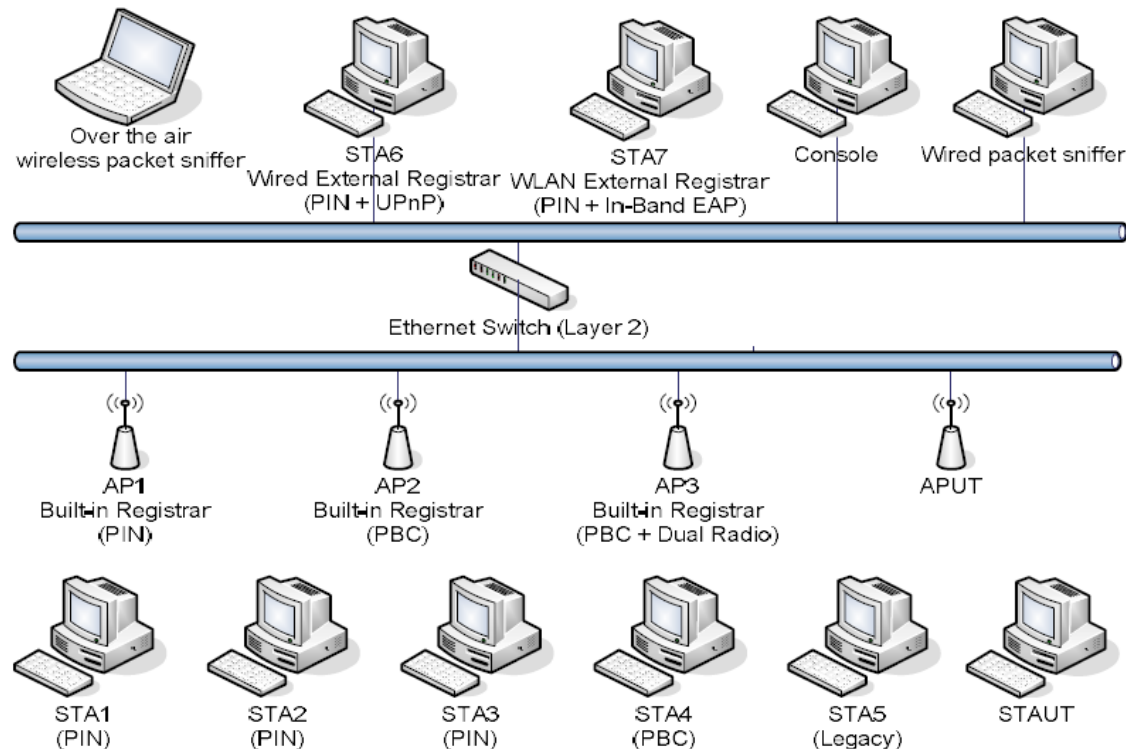
WI-FI TEST-OPTIONAL



Networking&Access-WPS2.0

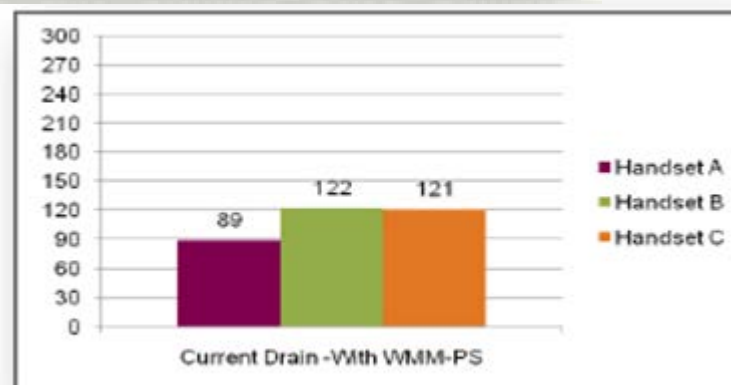
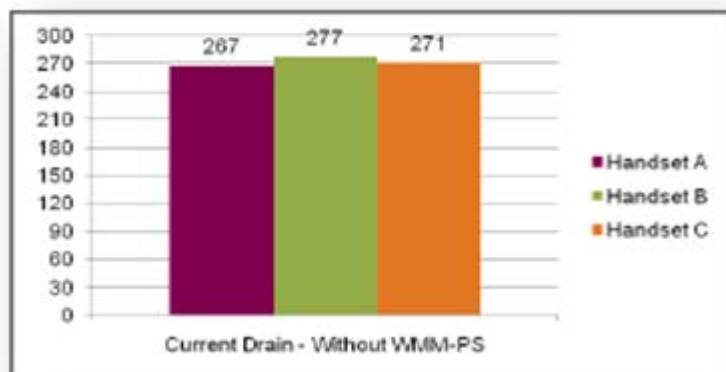
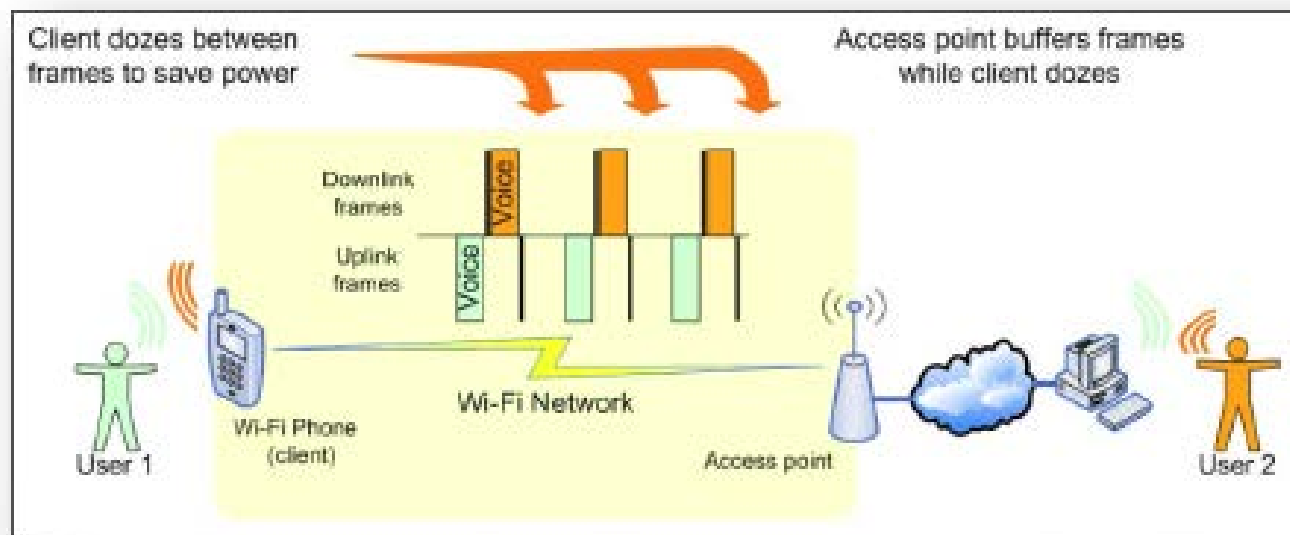


- Simple, Secure, Automatic Wi-Fi associate method
- 2 Associate mode:
 - Push-button method – 94% Product
 - PIN – All WPS product should support

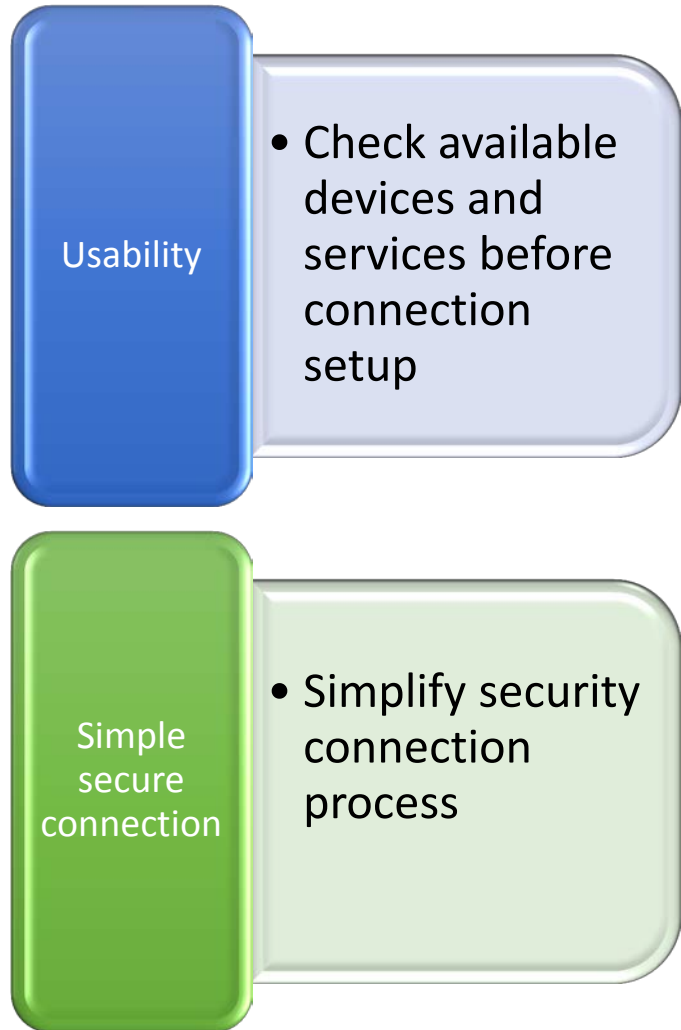


Application optimize

-WMM Power Save



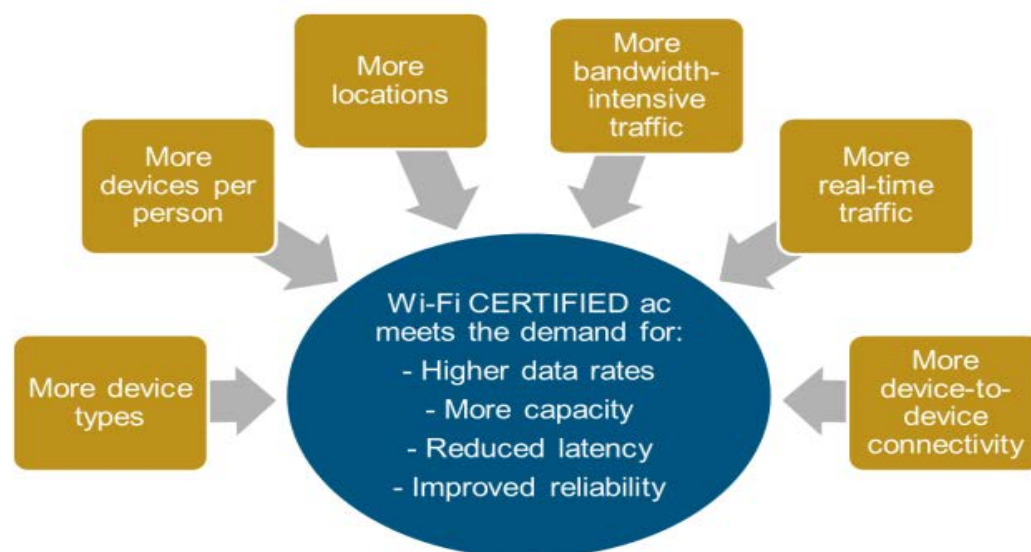
Networking-Wi-Fi Direct



Application & Service-Miracast

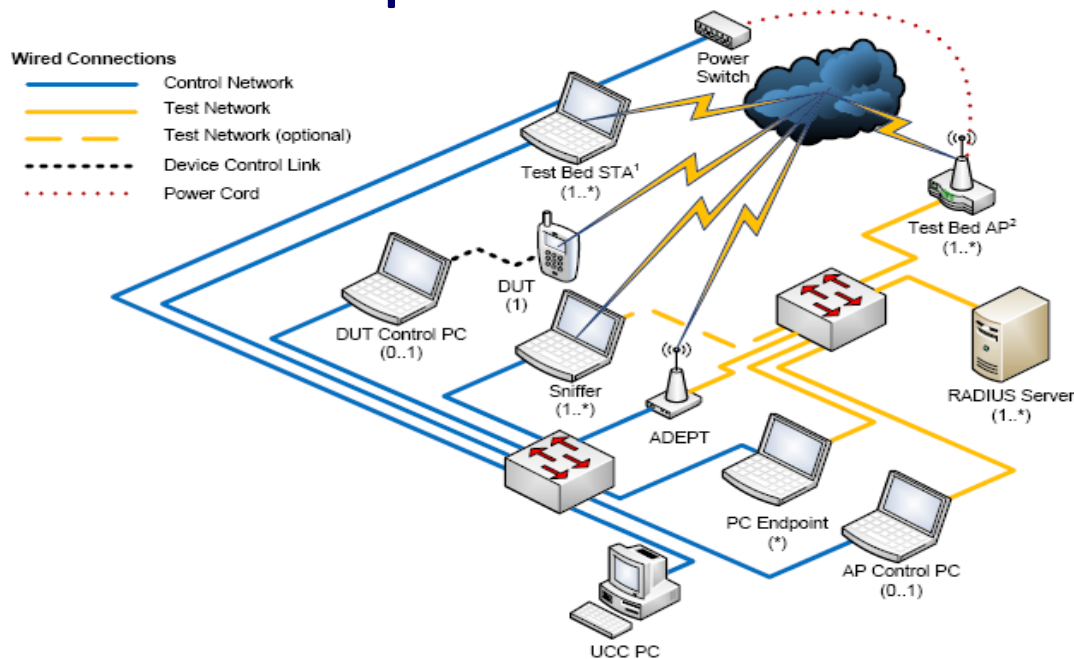


Physical Connection-802.11ac



Test Tool and Setup

- Test Tool: Sigma
- Developer: Wi-Fi Alliance
- Test Scope : 802.11n、802.11ac、WMM-PS、Direct、Miracast, etc.
- Function: Control test platform and DUT at the same time



WLAN Test Scope



Regulatory

- CN: NAL, CCC
- EU: CE (DFS)
- US: FCC (DFS)
- CA: IC, etc.

Wi-Fi Certification

- 802.11a/b/g/n/ac
- WPS 2.0
- Passpoint
- Miracast
- CWG, etc.

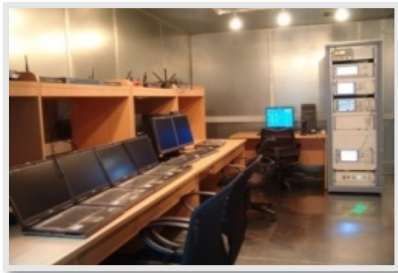
Operator

- Orange
- China Mobile
- China Unicom
- BGCTV

- The first Wi-Fi authorized Test Lab in China
- The first CWG Test Lab in the world



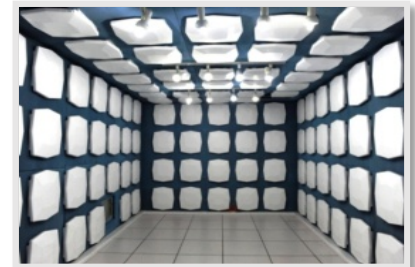
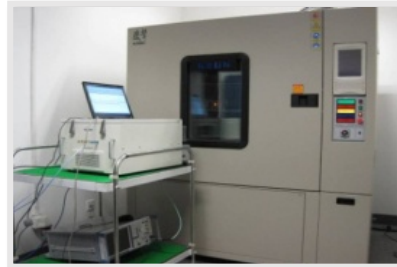
WLAN Test Setup



**Wi-Fi
Certification**

**Regulatory
Test**

**Operator
Test**



Agenda:



- Why Include Wireless Connectivity
- Regulatory Test of Wireless Connectivity
- Wi-Fi Standard, Technology and Testing
- **Bluetooth Standard, Technology and Testing**
- NFC Standard Technology and Testing



Bluetooth SIG



**Global non-profit
industry association**

**25,000+ Member
Companies**

***Standardization & Test
Specification Developer***

IP Owner

64+ Profiles

Bluetooth technology system



```
ip tftp source-interface GigabitEthernet0/1/20
tftp-server flashphones/MLDefault.cnf.vml alias MLDefault.cnf.vml
tftp-server flashphones/7911-7906/ten11.default.loads alias ten11.9-2-1THI-13.sbn
tftp-server flashphones/7911-7906/app11.9-2-1THI-13.sbn alias app11.9-2-1THI-13.sbn
tftp-server flashphones/7942-7962/ten62.default.loads alias ten62.default.loads
tftp-server flashphones/7942-7962/dsp42.9-2-1THI-13.sbn alias dsp42.9-2-1THI-13.sbn
tftp-server flashphones/7911-7906/jar11scop.9-2-1THI-13.sbn alias jar11scop.9-2-1THI-13.sbn
tftp-server flashphones/7942-7962/jar42scop.9-2-1THI-13.sbn alias jar42scop.9-2-1THI-13.sbn
tftp-server flashphones/7911-7906/SCP11.9-2-15.loads alias SCP11.9-2-15.loads
tftp-server flashphones/7942-7962/SCP42.9-2-15.loads alias SCP42.9-2-15.loads
tftp-server flashphones/7942-7962/cnv42scop.9-2-1THI-13.sbn alias cnv42scop.9-2-1THI-13.sbn
tftp-server flashphones/7911-7906/cnv11scop.9-2-1THI-13.sbn alias cnv11scop.9-2-1THI-13.sbn
tftp-server flashphones/7942-7962/cnv42.9-2-1THI-13.sbn alias cnv42.9-2-1THI-13.sbn
tftp-server flashphones/7911-7906/cnu11.9-2-1THI-13.sbn alias cnu11.9-2-1THI-13.sbn
tftp-server flashphones/7942-7962/app42.9-2-1THI-13.sbn alias app42.9-2-1THI-13.sbn
```

Host
subsystem

Protocol Stack

Hardware
+
Firmware

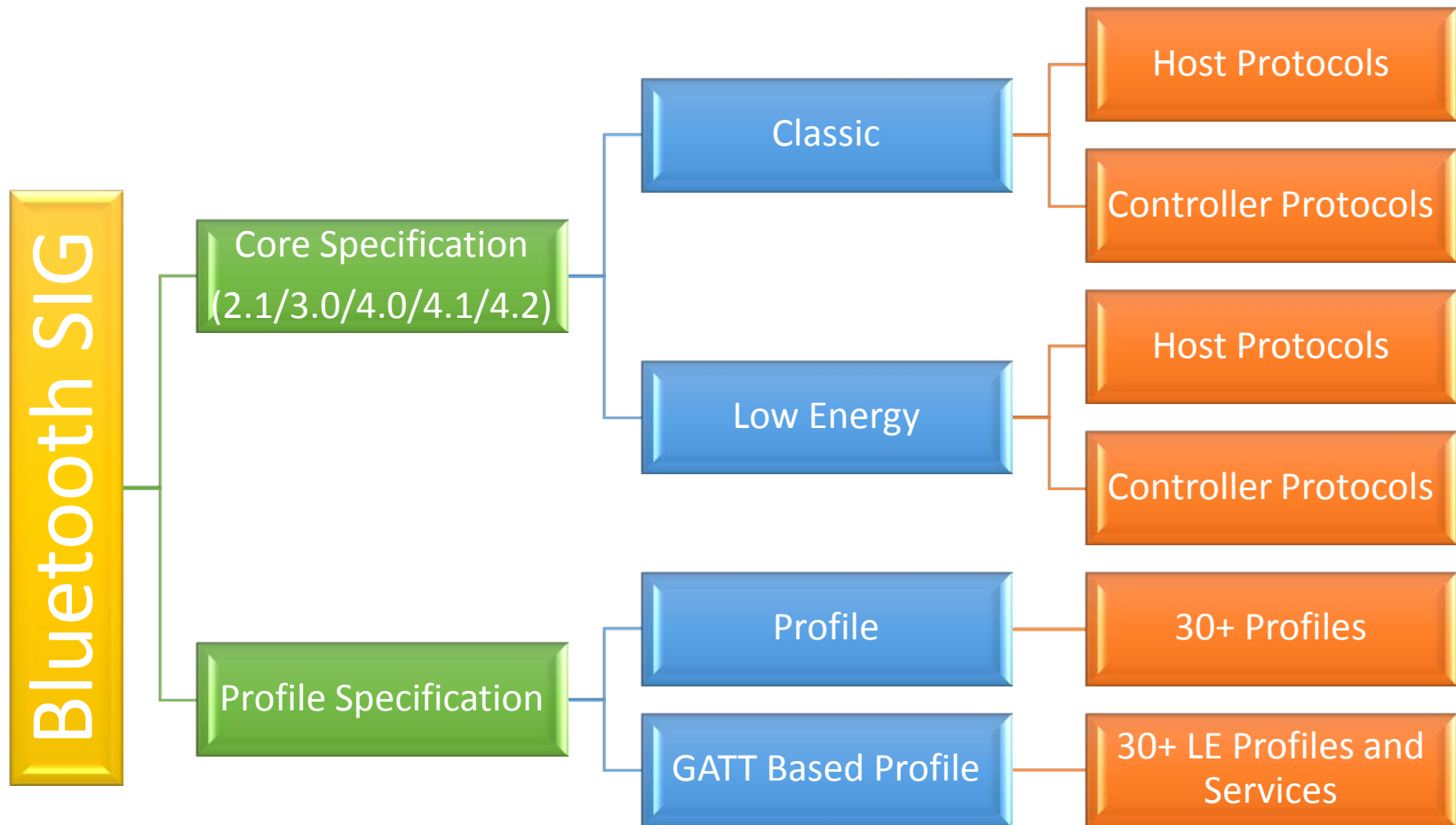
Controller
subsystem



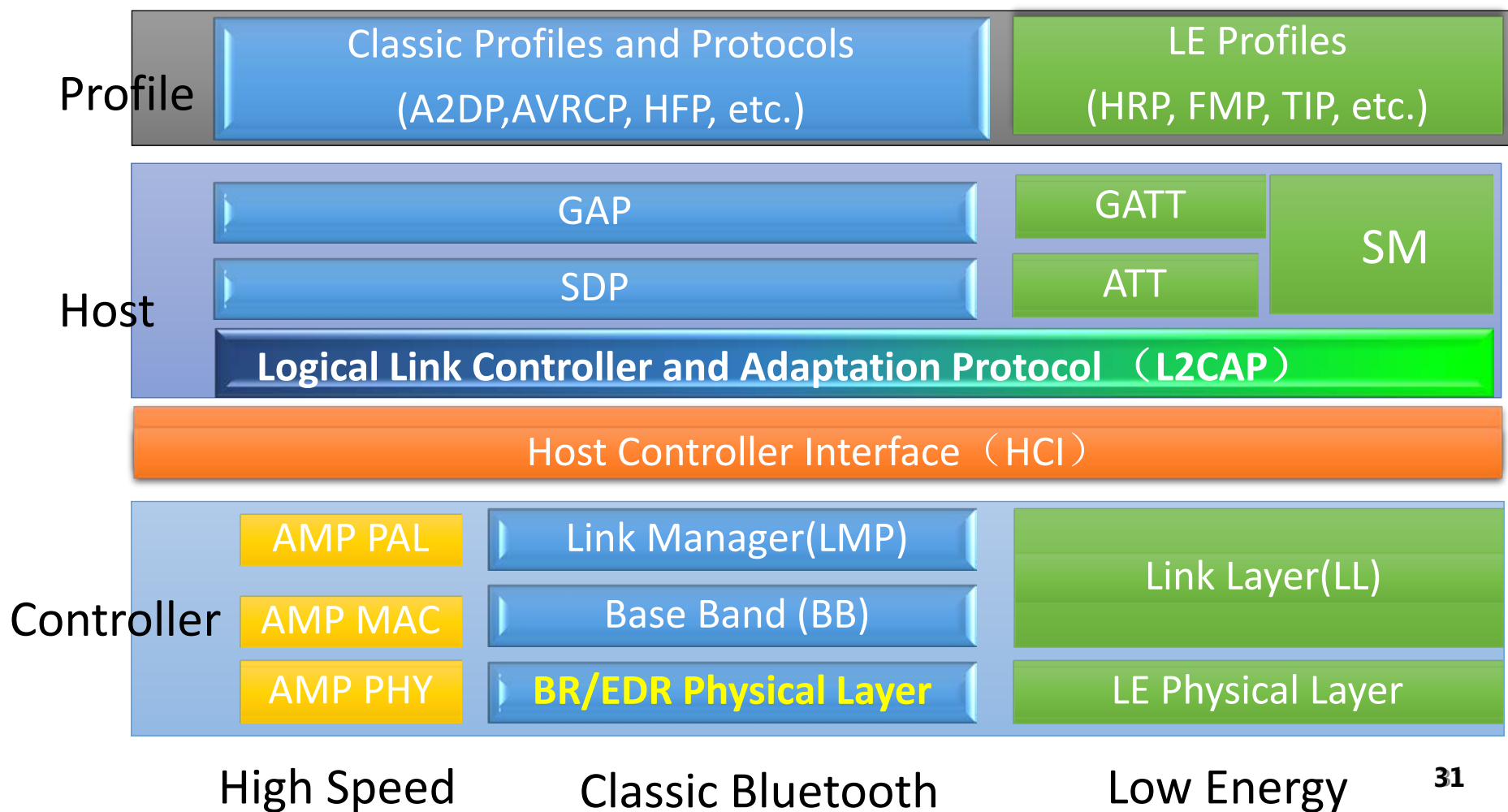
Application
+
Services

Profile
subsystem

Bluetooth Standard System



Bluetooth Technology Block Diagram



Bluetooth Technology Fact Sheet

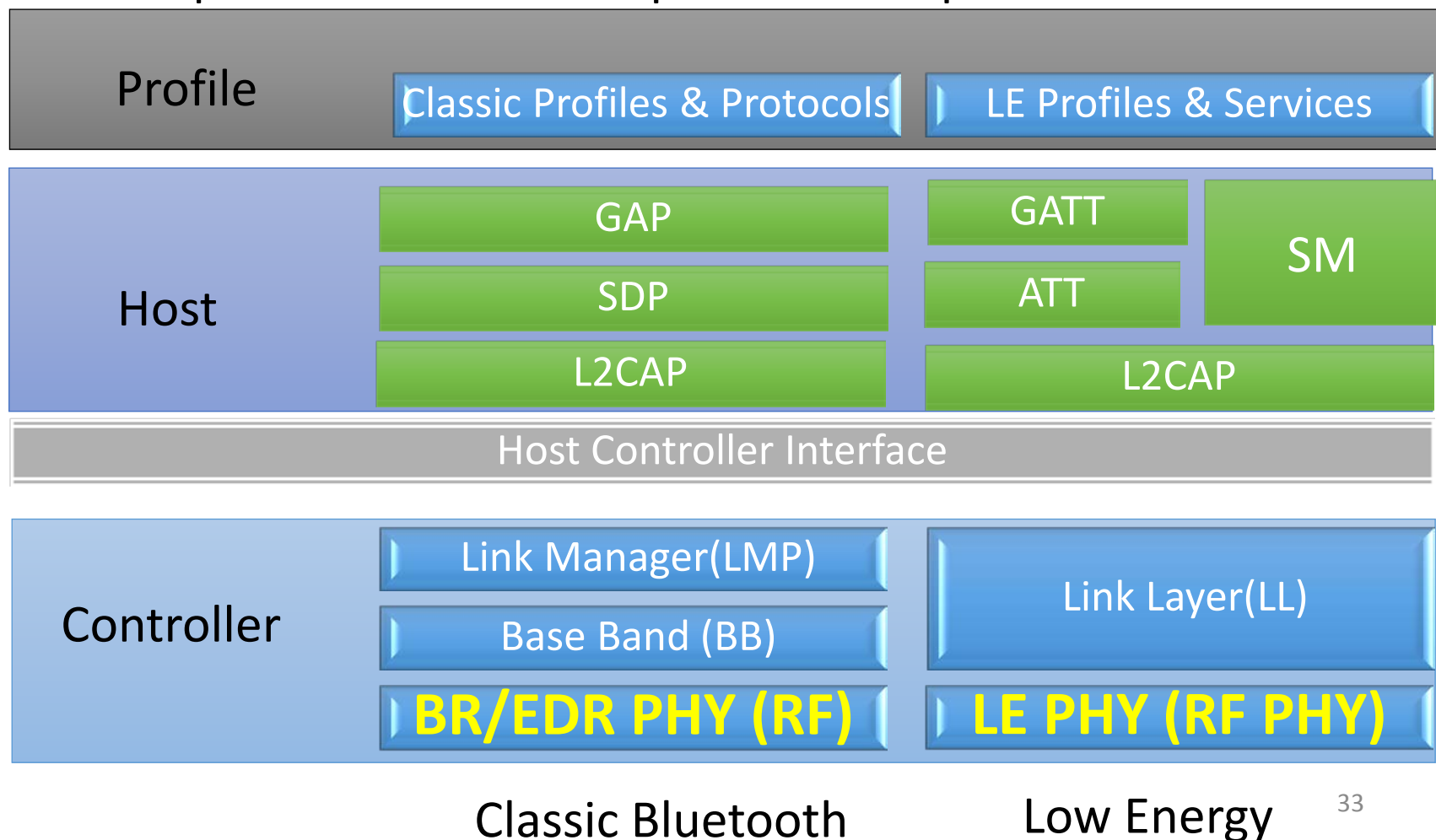


	Bluetooth BR/EDR /HS	Bluetooth Low Energy
Radio Frequency	2.4GHz ISM	
Range	10 to meters	10 to 100+ meters
Data Rate	1~3Mbps (Classic) >400 Mbps (AMP, 802.11n)	1 Mbps
Nodes	7	Unlimited
Security	56b E0	128b AES
Robustness	Adaptive frequency hopping	
Voice Capable	Yes	No
Network Topology	Scatternet	Star-bus
Power Consumption	1 as the reference	0.01 to 0.5
Service Discovery	Yes	Yes
Latency(from non connected state)	100ms	<3ms

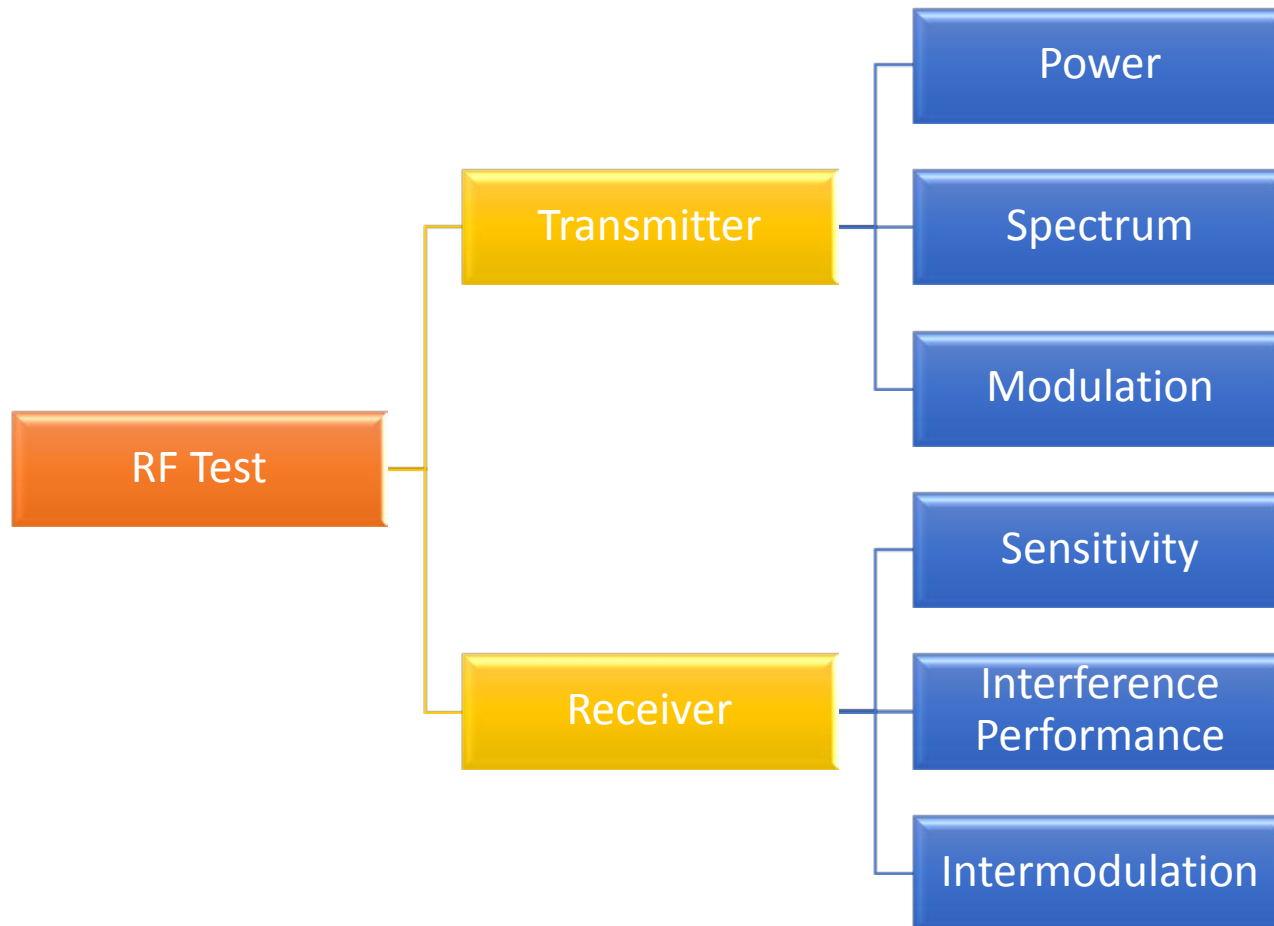
Bluetooth Test Specification



- Developer: Bluetooth SIG
- A Test Specification for each protocol and profile

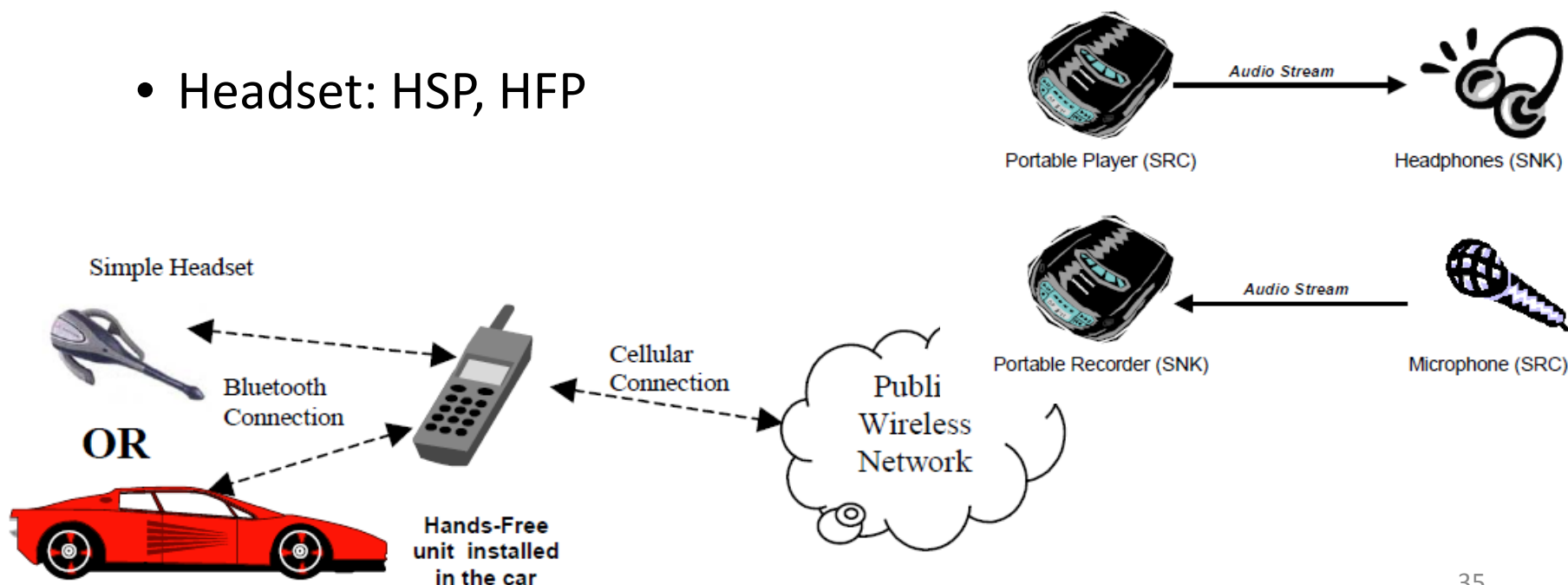


RF Test parameters



Profiles-Example (1)

- The most Competitive Section of Bluetooth
- More than 64 profiles are developed
 - Audio/Video: A2DP, AVRCP, VDP
 - Headset: HSP, HFP

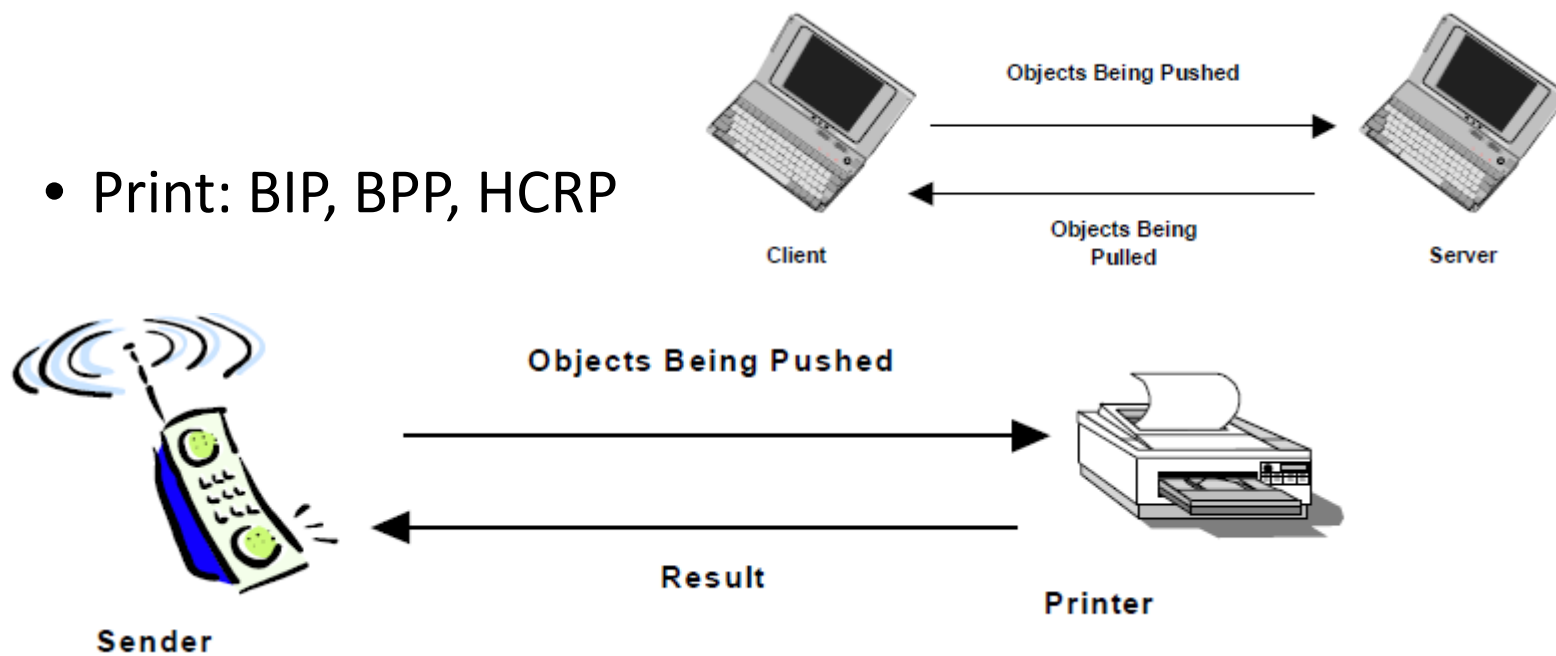


Profiles-Example(2)

- More than 64 profiles are developed

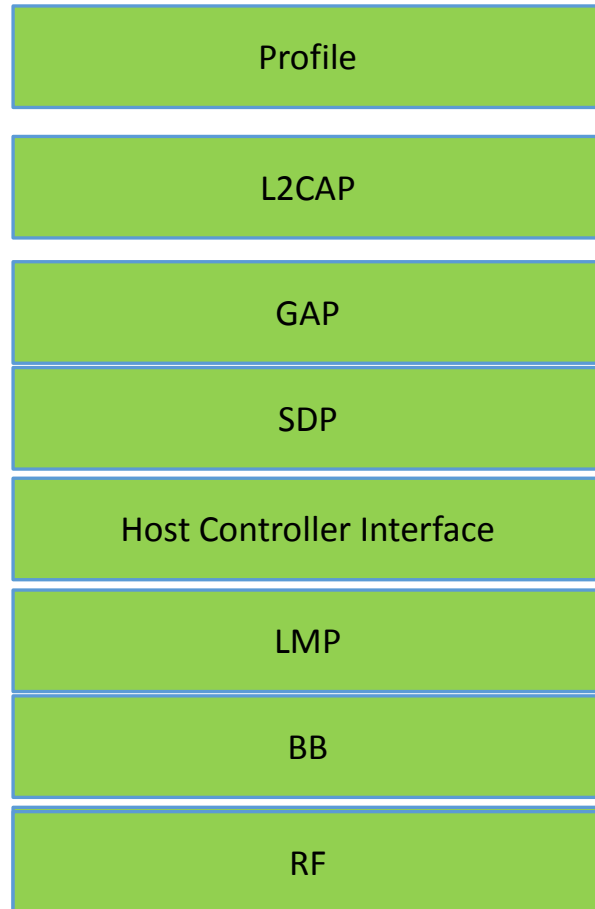
- File Transfer: FTP, OPP, PBAP

- Print: BIP, BPP, HCRP



- Others: HID, DUN, PAN, SYNC...

Test Tool of Classic Bluetooth



PTS



TTCN Tester
Eyesight BITE T1212



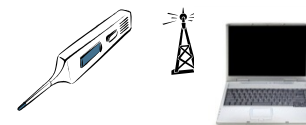
RF Test System



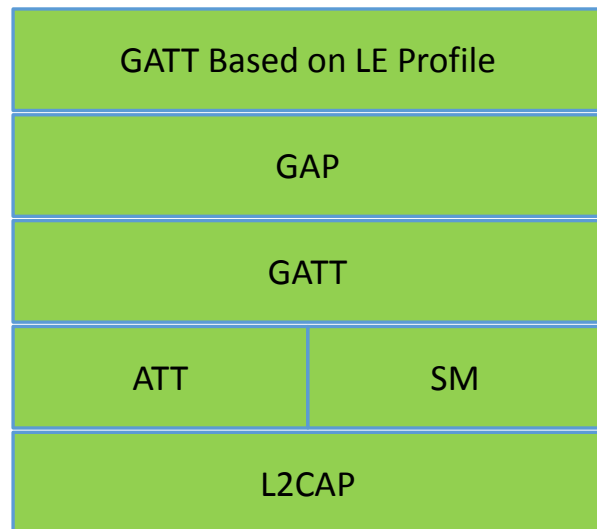
Test Tool for Bluetooth Low Energy



PTS



LE Profile Tester



GATT Based on LE Profile

GAP

GATT

ATT

SM

L2CAP

Host Controller Interface

Link Layer

Physical Layer

PTS



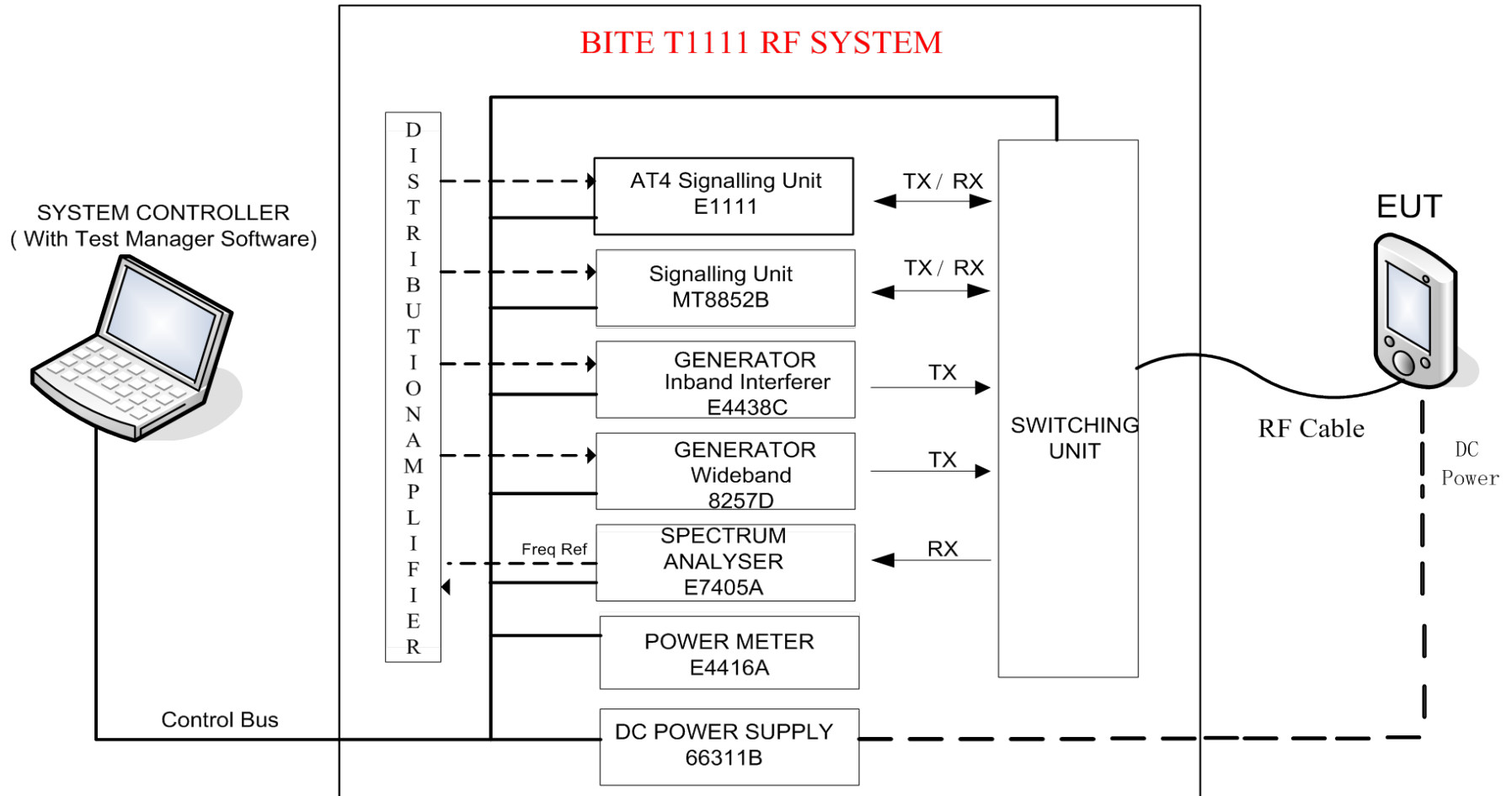
TTCN Tester
Eyesight BITE T1212



RF Test System



Bluetooth RF Test System



Bluetooth Test Scope



Regulatory

- CN: NAL, CCC
- EU: CE
- US: FCC
- CA: IC, etc.

Bluetooth Cert.

- RF
- Protocol
- Profile Interoperability

Operator

- CTIA
- China Mobile
- BGCTV

- The only CTIA Authorized Bluetooth Test Lab in China



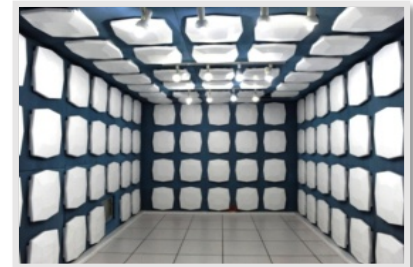
Bluetooth Test Setup



**Bluetooth
Certification**

**Regulatory
Test**

**Operator
Test**



蓝牙-测试产品类型

150
1865-2015

CAICT
中国信息通信研究院
China Academy of Information and Communications Technology



移动电话



蓝牙键盘



车载免提



蓝牙耳机



打印机



鼠标



蓝牙音箱



笔记本电脑

Agenda:



- Why Include Wireless Connectivity
- Regulatory Test of Wireless Connectivity
- Bluetooth Standard, Technology and Testing
- Wi-Fi Standard, Technology and Testing
- **NFC Standard, Technology and Testing**



NFC Forum



**Non-profit industry
association**

**More Than 180
Member
Companies**

*Secure
Connectivity*

**Hundred of
Product Certified**

**More Than 20
Specifications**

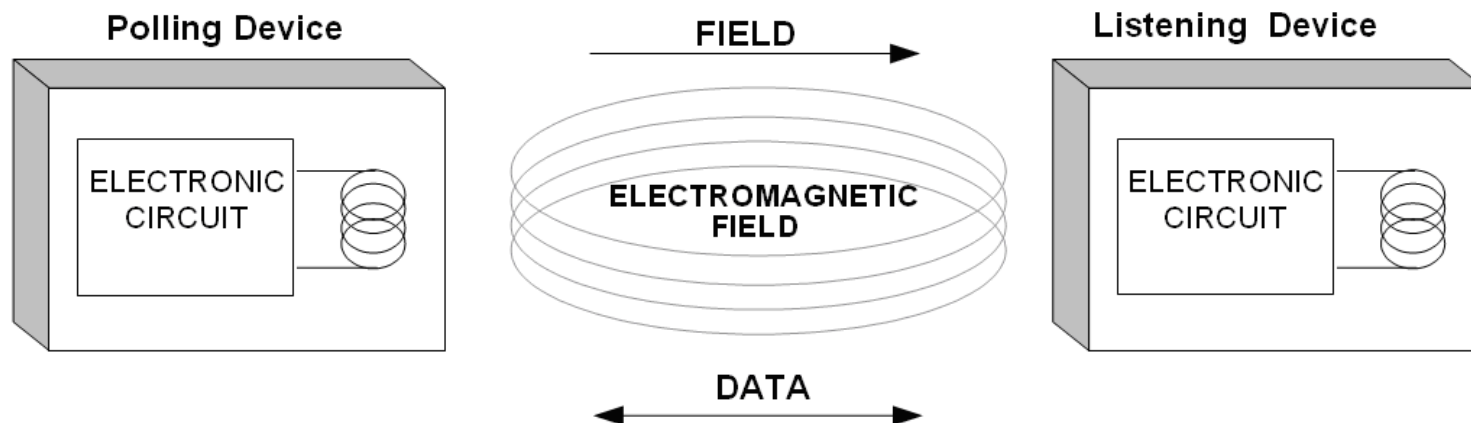
NFC Standard Systems



ECMA	ISO / IEC	ETSI	Name and Content
ECMA340	ISO/IEC 18092 Front-end Configuration	NFC-FEC ISO/IEC 16353 ECMA-390	NFCIP-1 NFC In ISO/IEC 14443 ISO/IEC 10373-6
ECMA352	ISO/IEC 21481 Wireless Interface to Secure Element	NFC-WI ISO/IEC 28361 ECMA-373	NFCIP-2 NFC In -2
ECMA362	ISO/IEC 23917	ETSI TS 102 334	NFCIP-1 Protocol
ECMA356	ISO/IEC 22536 Contactless Interface and Protocol	NFCIP-1 ISO/IEC 18092 (ETSI EN 302 190) ECMA-340	NFCIP-1: RF Inter
ECMA373	ISO/IEC 28361	ETSI TS 102 190	NFC wi
ECMA385	ISO/IEC 13157 RF Interface Test Methods ISO/IEC 22536 (10373-6) ECMA-356		NFCIP-1 Security Service and Protocol Test Methods ISO/IEC 23917 ECMA-362
ECMA386		ETSI TS 102 346	ETSI TS 102 394

NFC Tx Principle

- Magnetic inductive coupling and coil antennas are used for polling and listening devices.
- NFC working frequency $f_c = 13.56$ MHz, wireless power is provided to passive (listening) devices.
- Data rate is 106 kbps ($f_c/128$), 212 kbps ($f_c/64$) and 424 kbps ($f_c/32$)



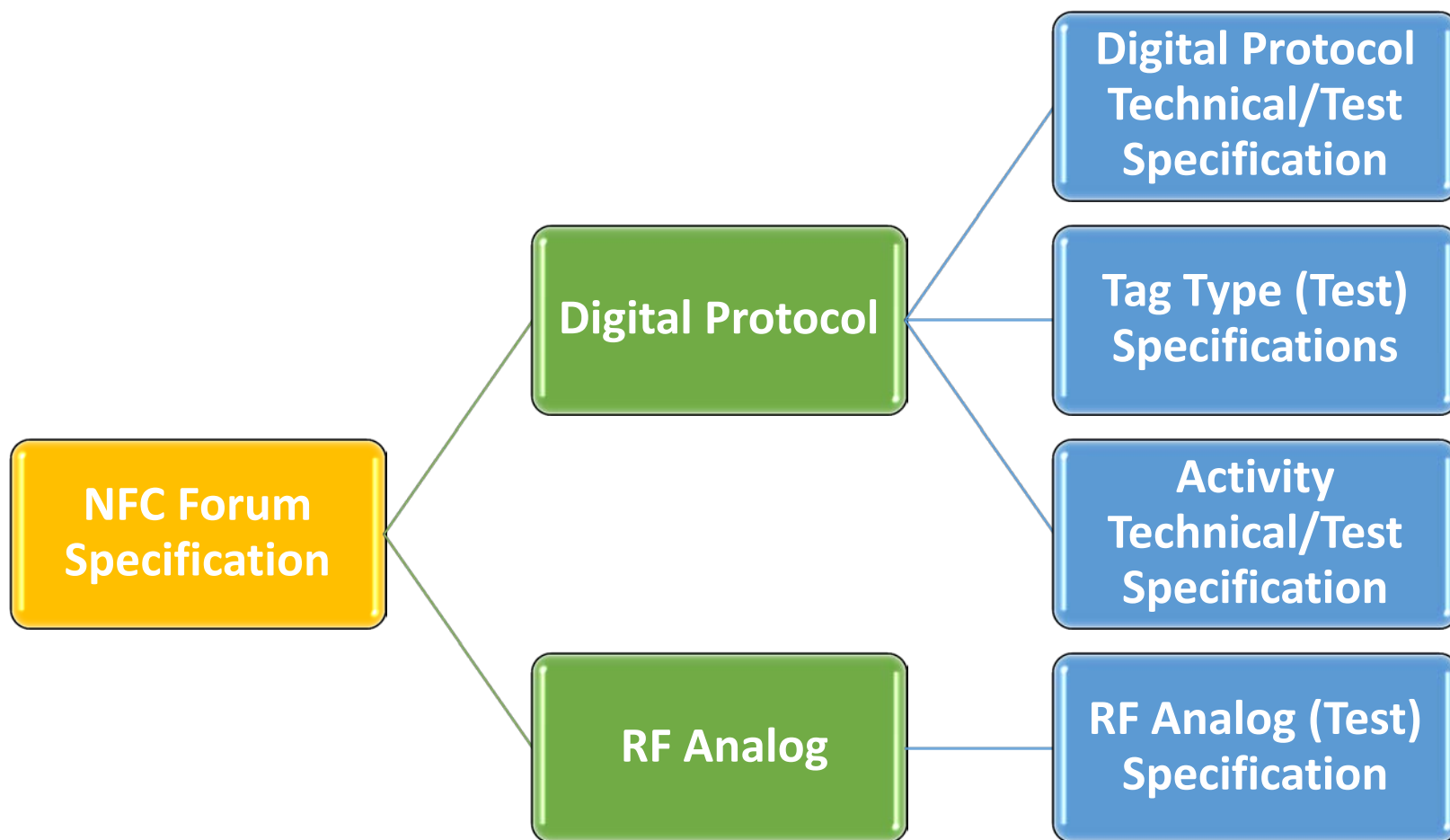
NFC Tx Technologies



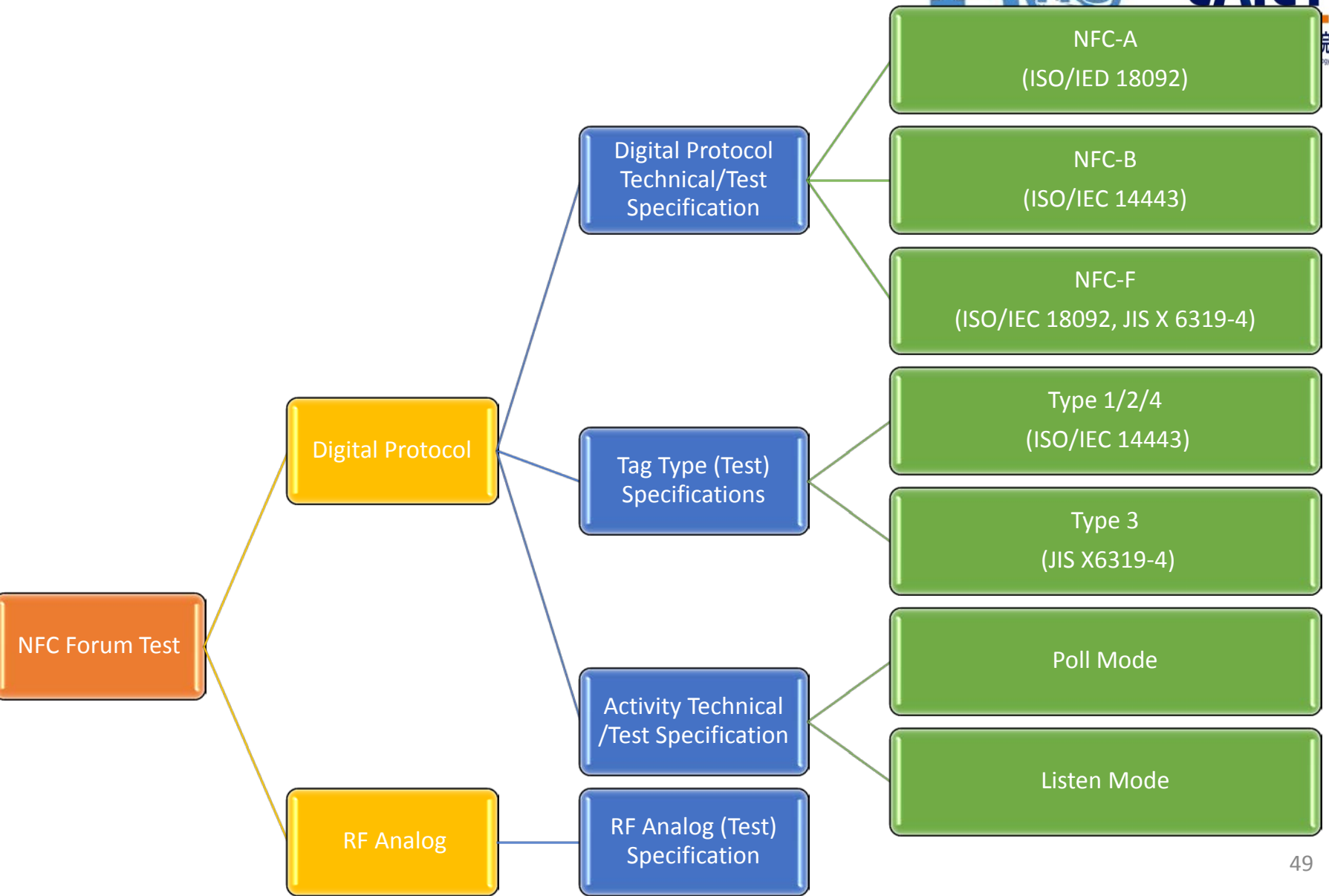
NFC Type		Coding	Modulation	Data rate	Frequency
NFC-A	Uplink	Modified Miller	2-ASK 100%	106 kbit/s	13.56 MHz
	Downlink	Manchester	Load modulation (ASK)	106 kbit/s	13.56 MHz $\pm$ 848 kHz subcarrier
NFC-B	Uplink	NRZ-L	2-ASK 10%	106 kbit/s	13.56 MHz
	Downlink	NRZ-L	Load modulation (BPSK)	106 kbit/s	13.56 MHz $\pm$ 848 kHz subcarrier
NFC-F	Uplink	Manchester	2-ASK 10%	212 / 424 kbit/s	13.56 MHz
	Downlink	Manchester	Load modulation (ASK)	212 / 424 kbit/s	13.56 MHz

Note: Uplink = Poller to Listener; Downlink = Listener to Poller

NFC Specifications

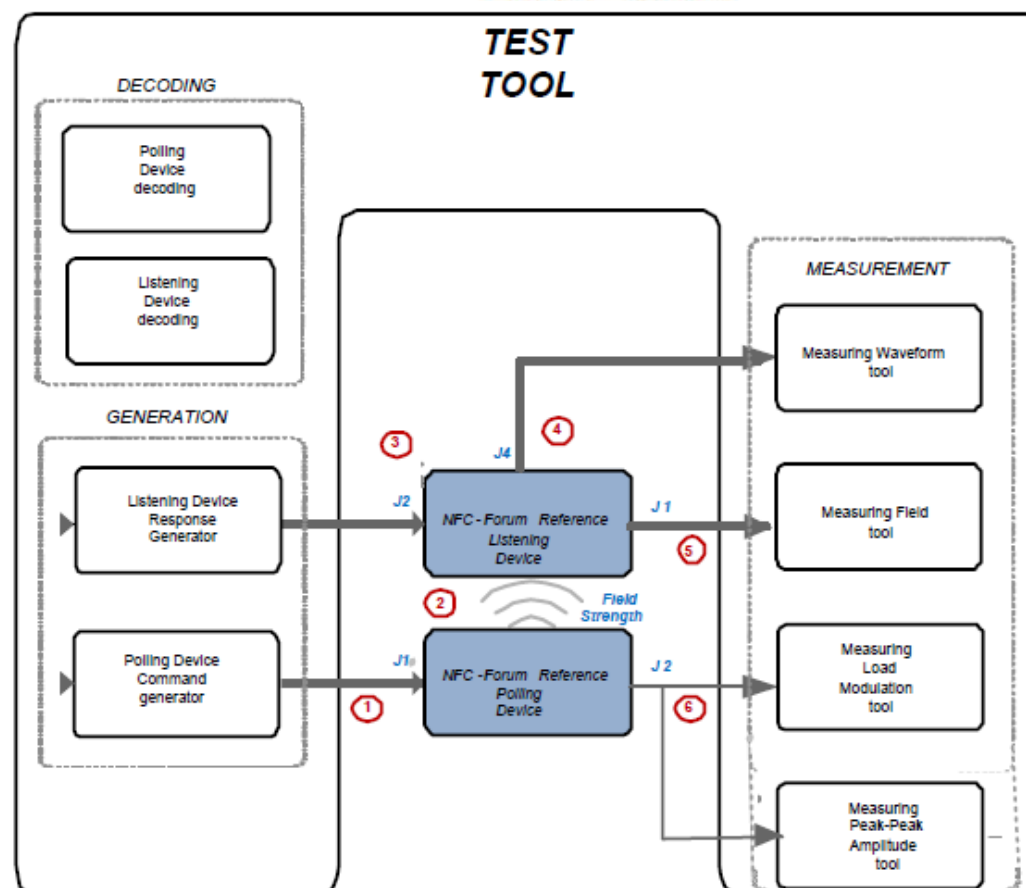


NFC Specifications

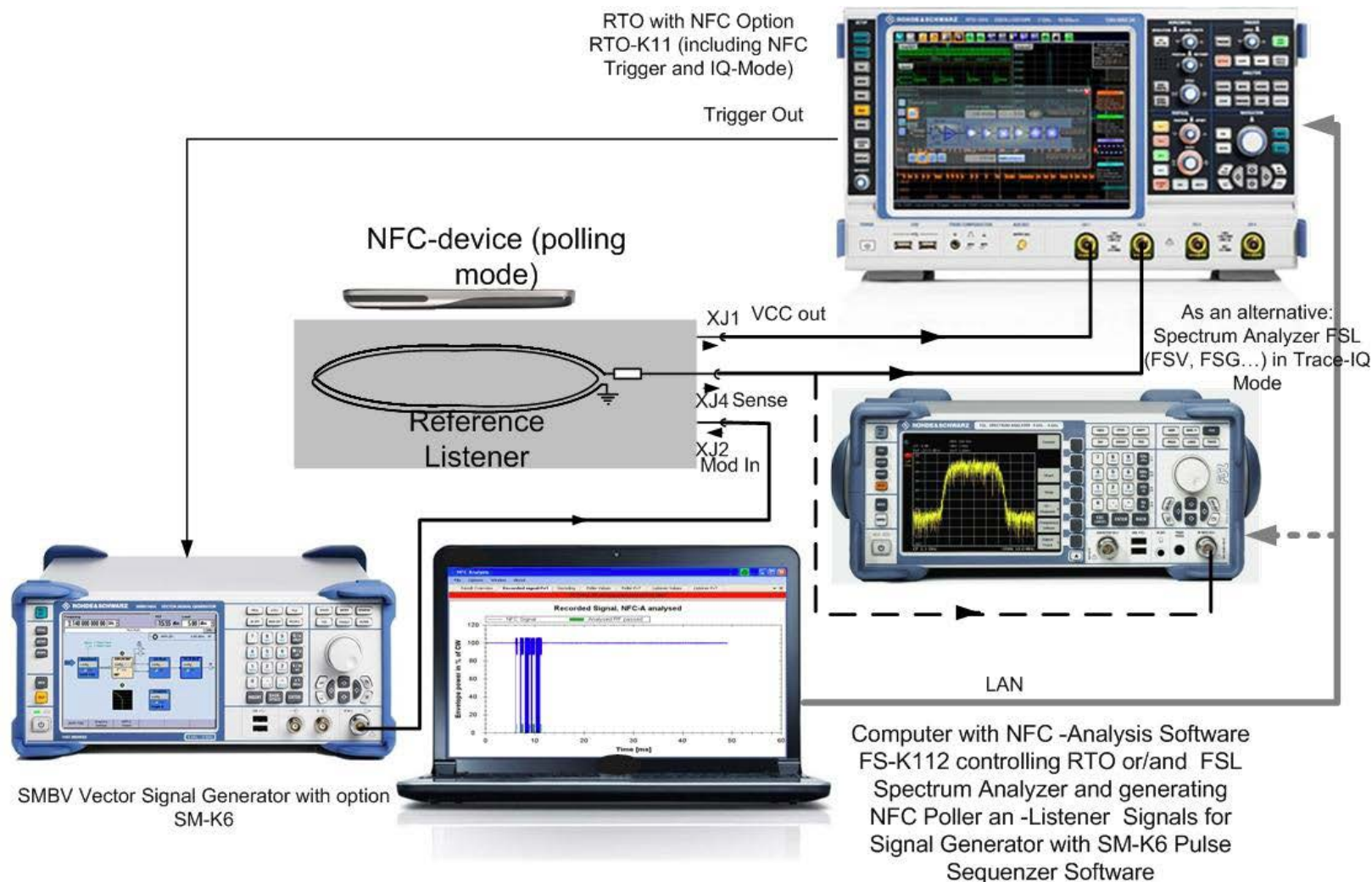


Test Tool Block Diagram

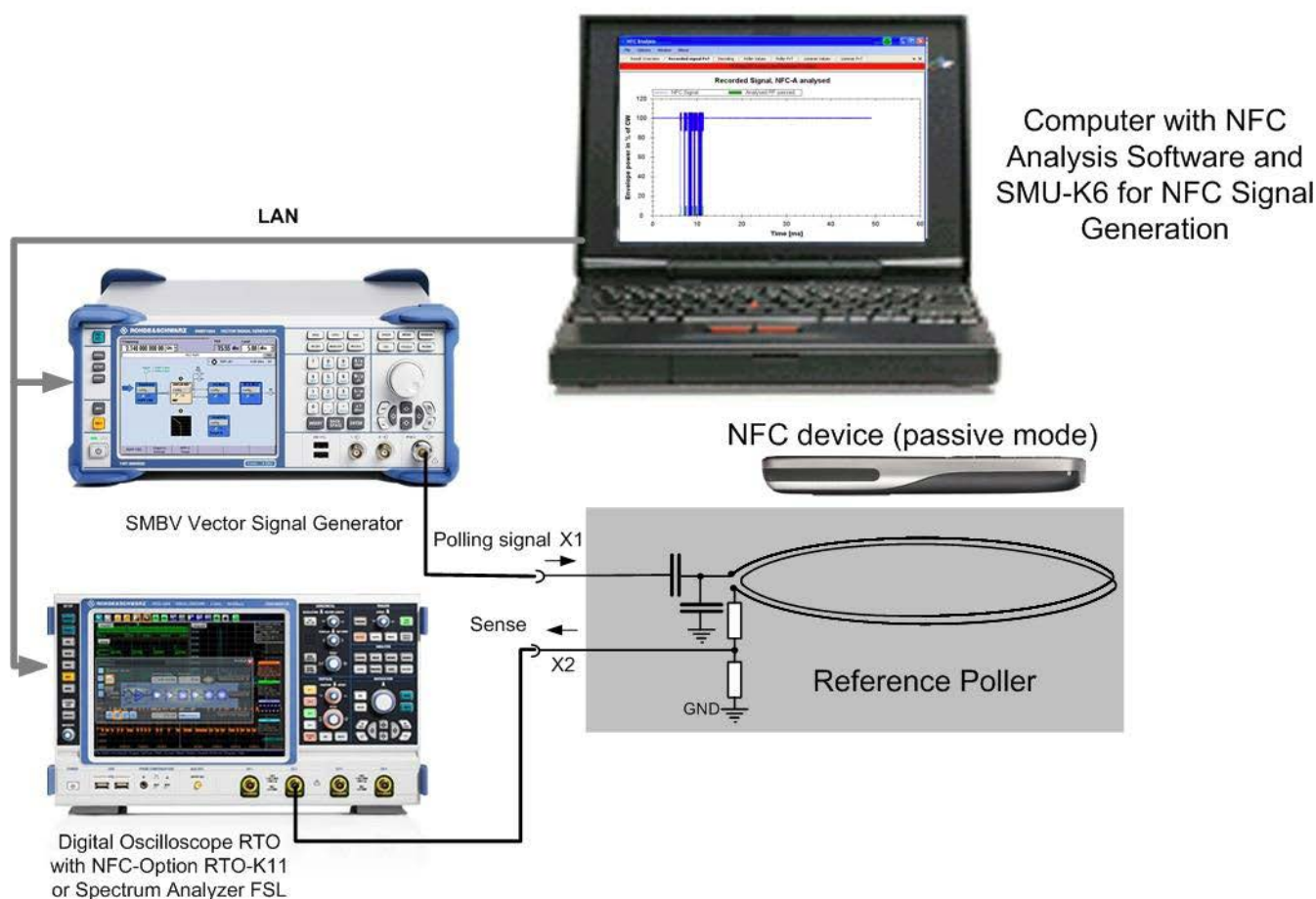
1. Generating data corresponding to a Listening Device
2. Field Strength
3. Generating waveforms corresponding to a Polling Device ☐
4. Measuring waveform characteristics of a Polling Device command
5. Measuring field strength
6. Measuring load modulation amplitude
7. Decoding the polling device
8. Decoding the listening device
9. Measuring Peak to Peak amplitude tool



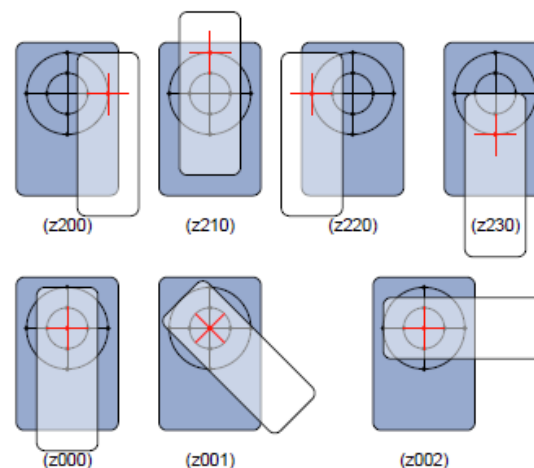
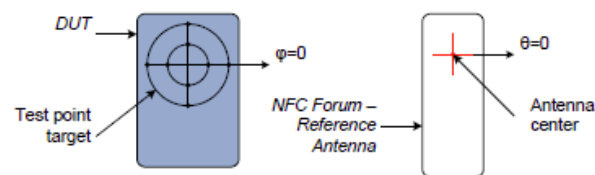
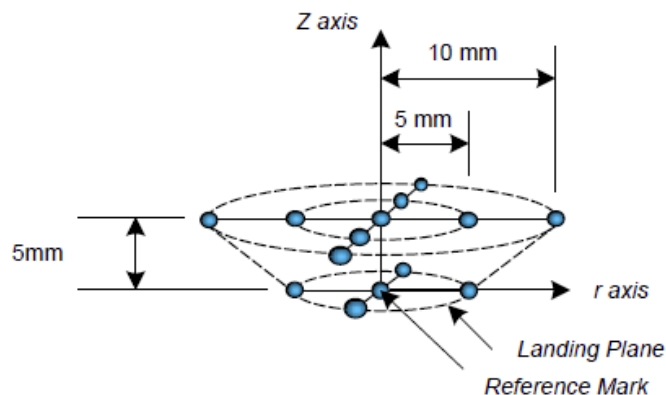
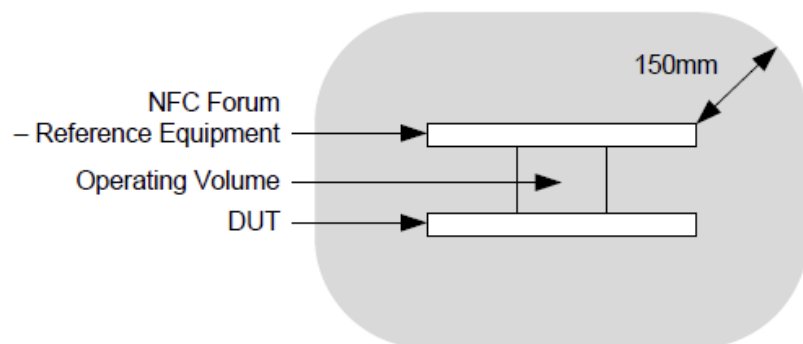
Polling Device Test Setup



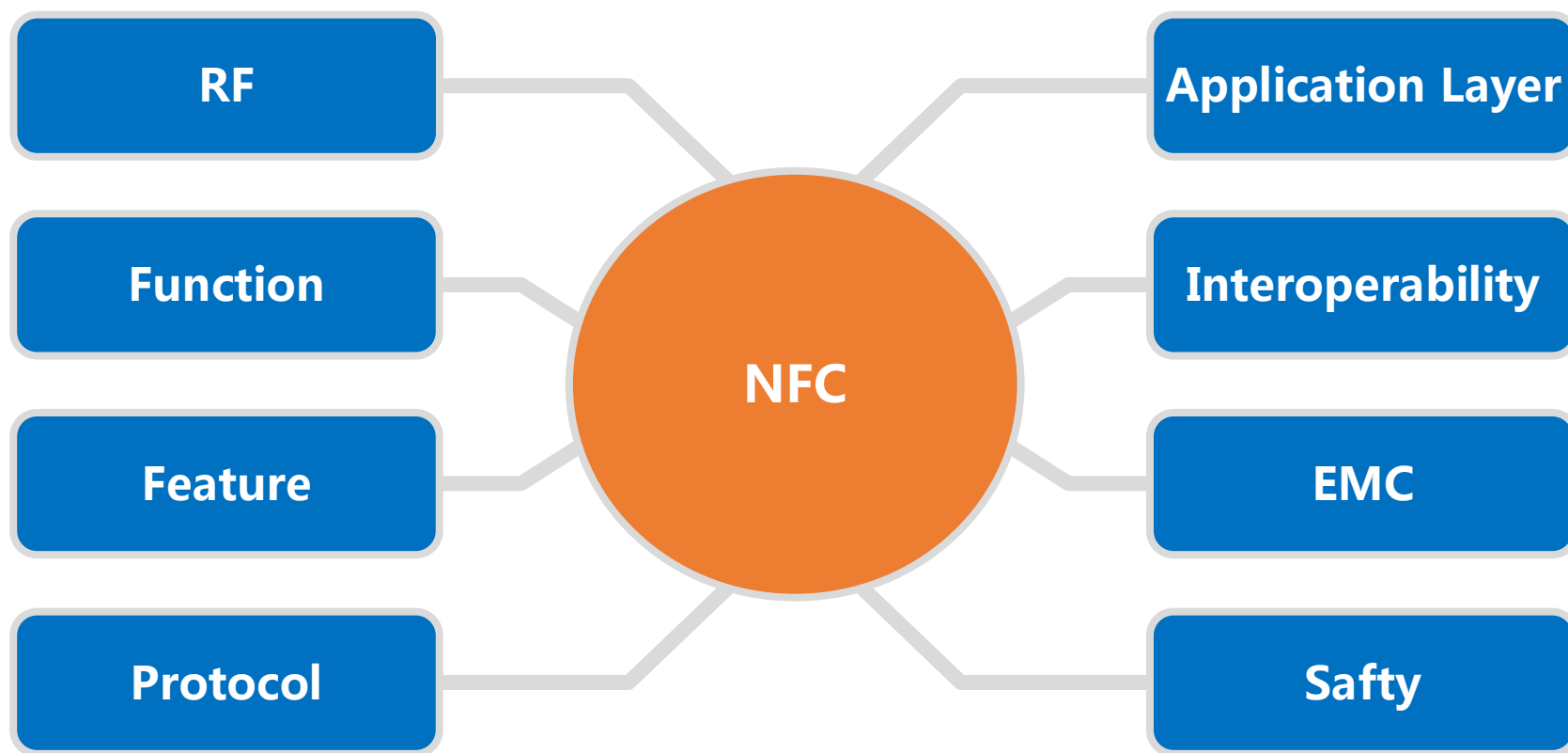
Listening device Test Setup



Positioning for RF Test



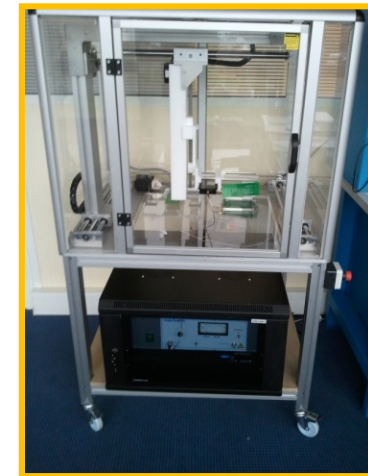
NFC-Test Scope



Test Equipment



- Test Systems: UT3 , CTS , AT4 , FIME



DUT of NFC



Mobile Phone



Pad



Card



SIM Card



Reader



Consumer Electronics



- Working frequency of Wi-Fi are _____ and _____

A:Regulatory

C: Protocol Conformance

D: Interoperability

Please refer to Examination Paper for more questions

Exam questions:





Trainer: Julie Li

E-mail: lizhuofang@caict.ac.cn

Department: CTTL-Terminals

Address: No.52 Huayuan North Road, Haidian District, Beijing , 100191

Julie Li

lizhuofang@caict.ac.cn

No.52 Huayuan North Road, Haidian District , Beijing, 100191



Thank you

中国信息通信研究院 <http://www.caict.ac.cn>