

IEEE OEB Wireless Seminar
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Essential Bluetooth™
It's everywhere you want to be ...

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Agenda

- Applications of Bluetooth™ Technology
- How does Bluetooth™ work?
- Cost of Implementation
- Risks of Implementation
- Benefits of Bluetooth

Applications of Bluetooth™ Technology

Bluetooth Applications

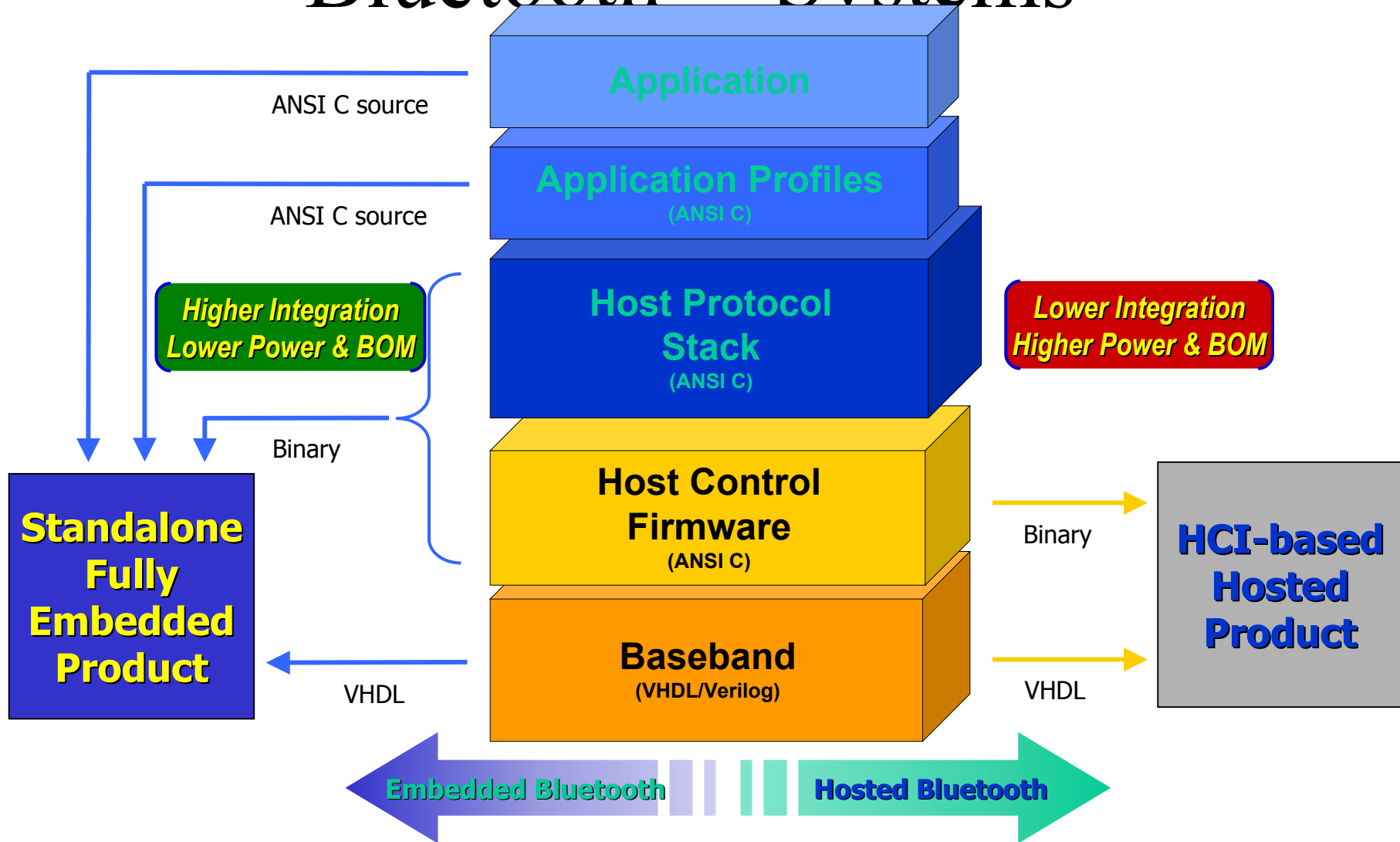


- Internet and email bridge
- Ad Hoc network via access point
- Home networking
- Hidden computing
- Wireless wallet
- Laptop and PDA to cell phone
- Headset
- Digital camera

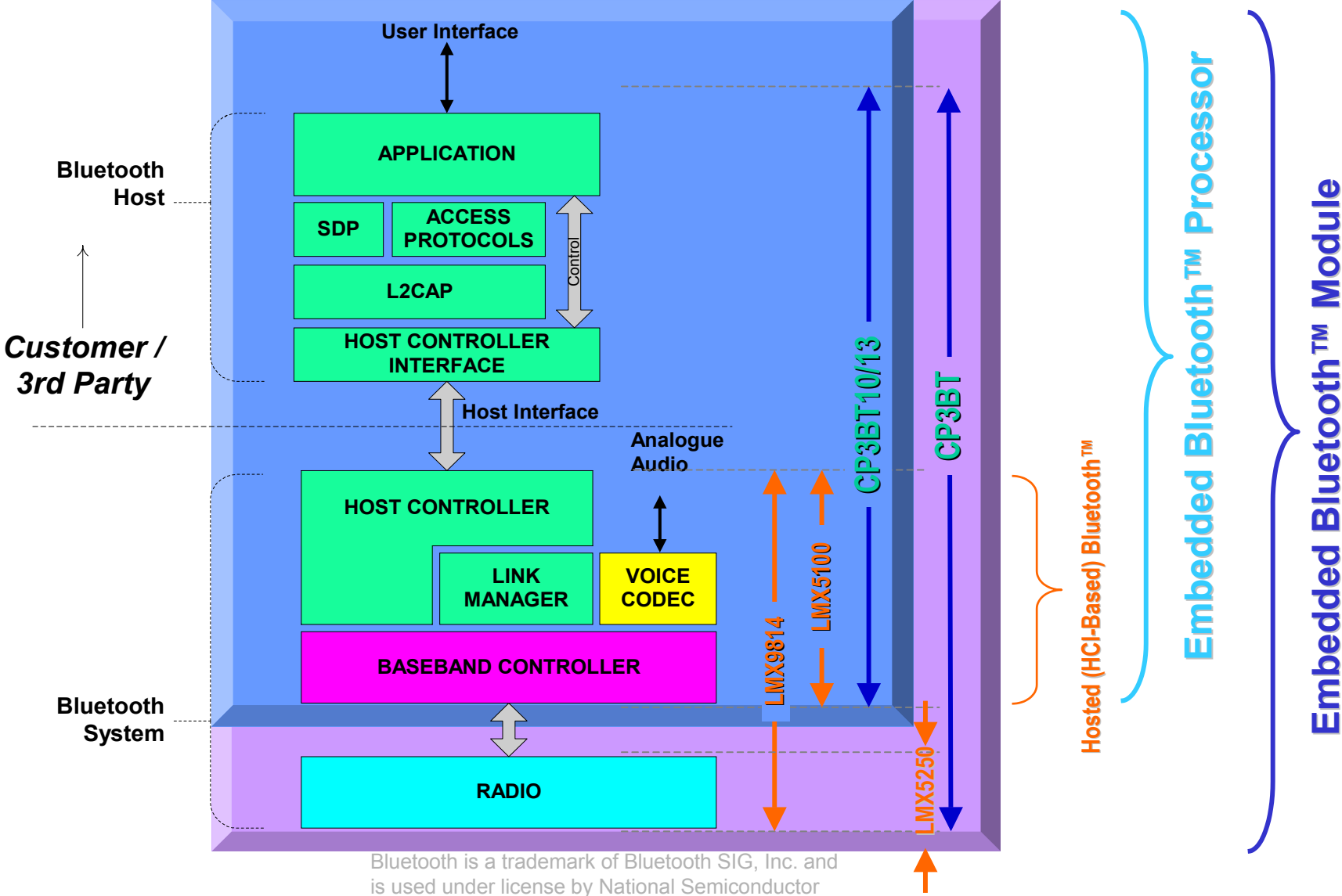
Embedded Bluetooth™

- Bluetooth™ Handsfree Modules
- Point of Sale
- Access Points
- Security Systems
- Fitness Equipment
- Instrument Panels
- Radio/Navigation User Interface

Bluetooth™ Systems

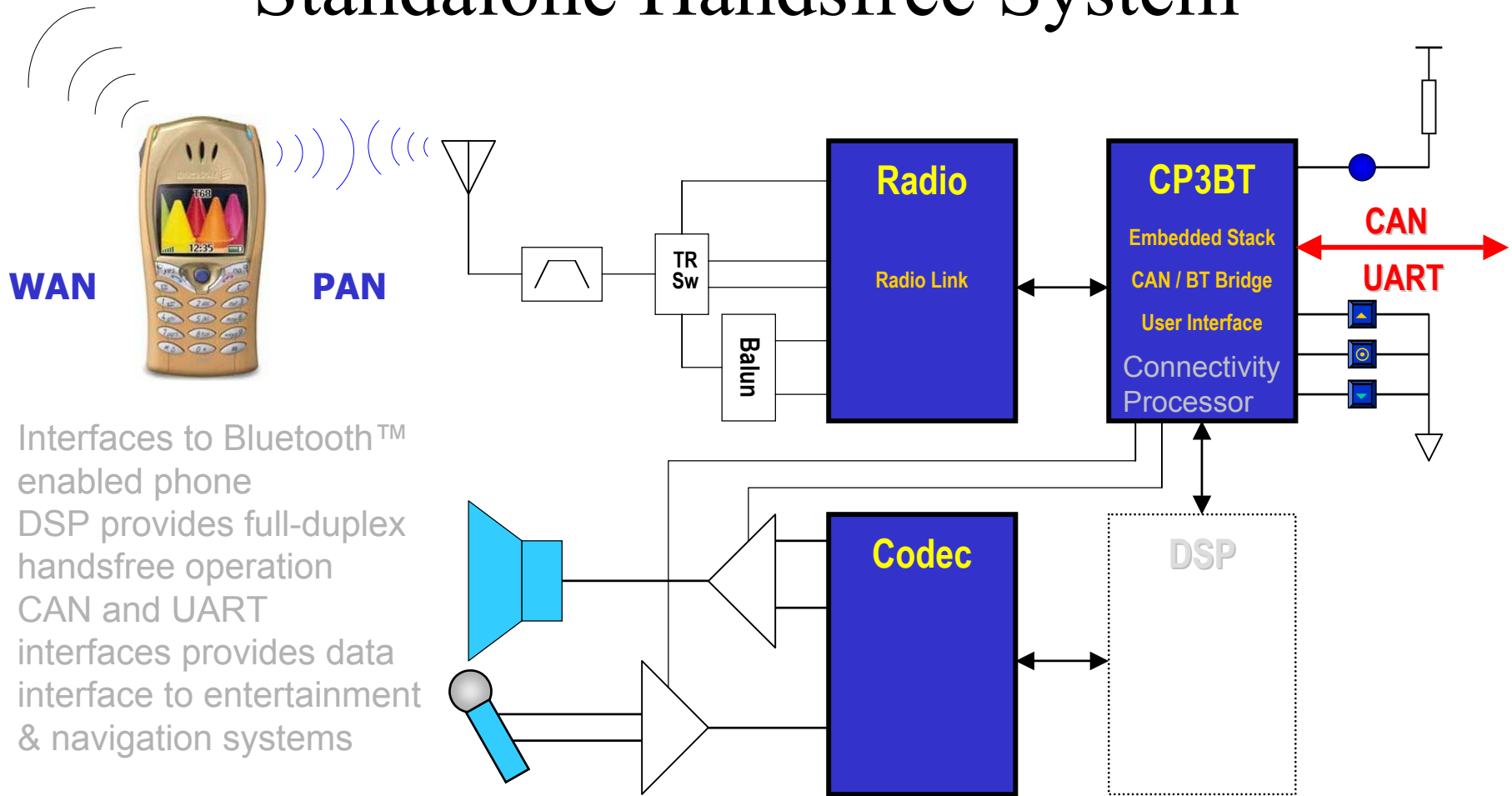


Bluetooth™ System Solutions



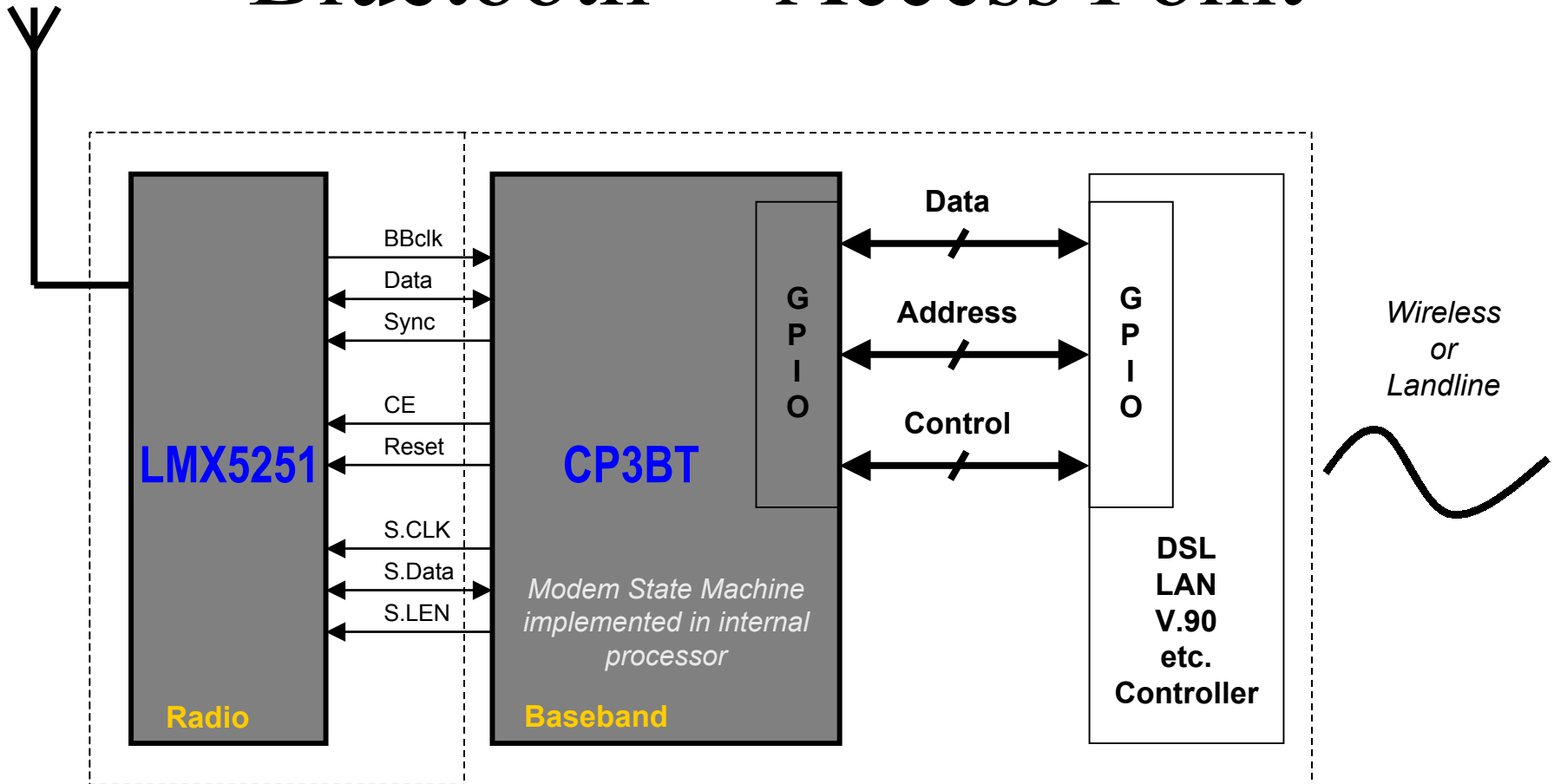
Telematics System Diagram

Standalone Handsfree System



- Interfaces to Bluetooth™ enabled phone
- DSP provides full-duplex handsfree operation
- CAN and UART interfaces provides data interface to entertainment & navigation systems

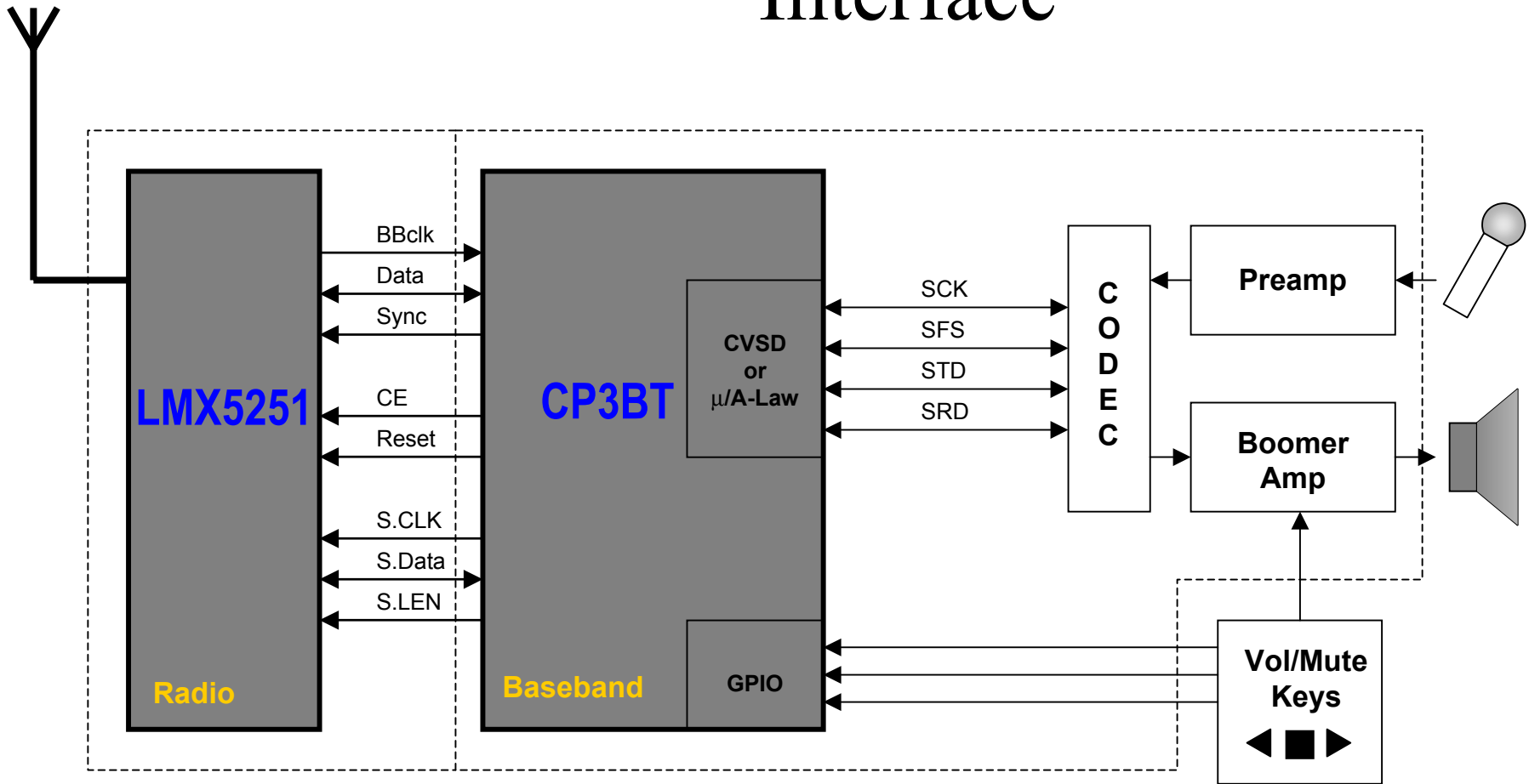
Bluetooth™ Access Point



Allows connections to virtually any wireless or landline modem controller

Bluetooth™ Headset

Headset Profile, Application & Interface



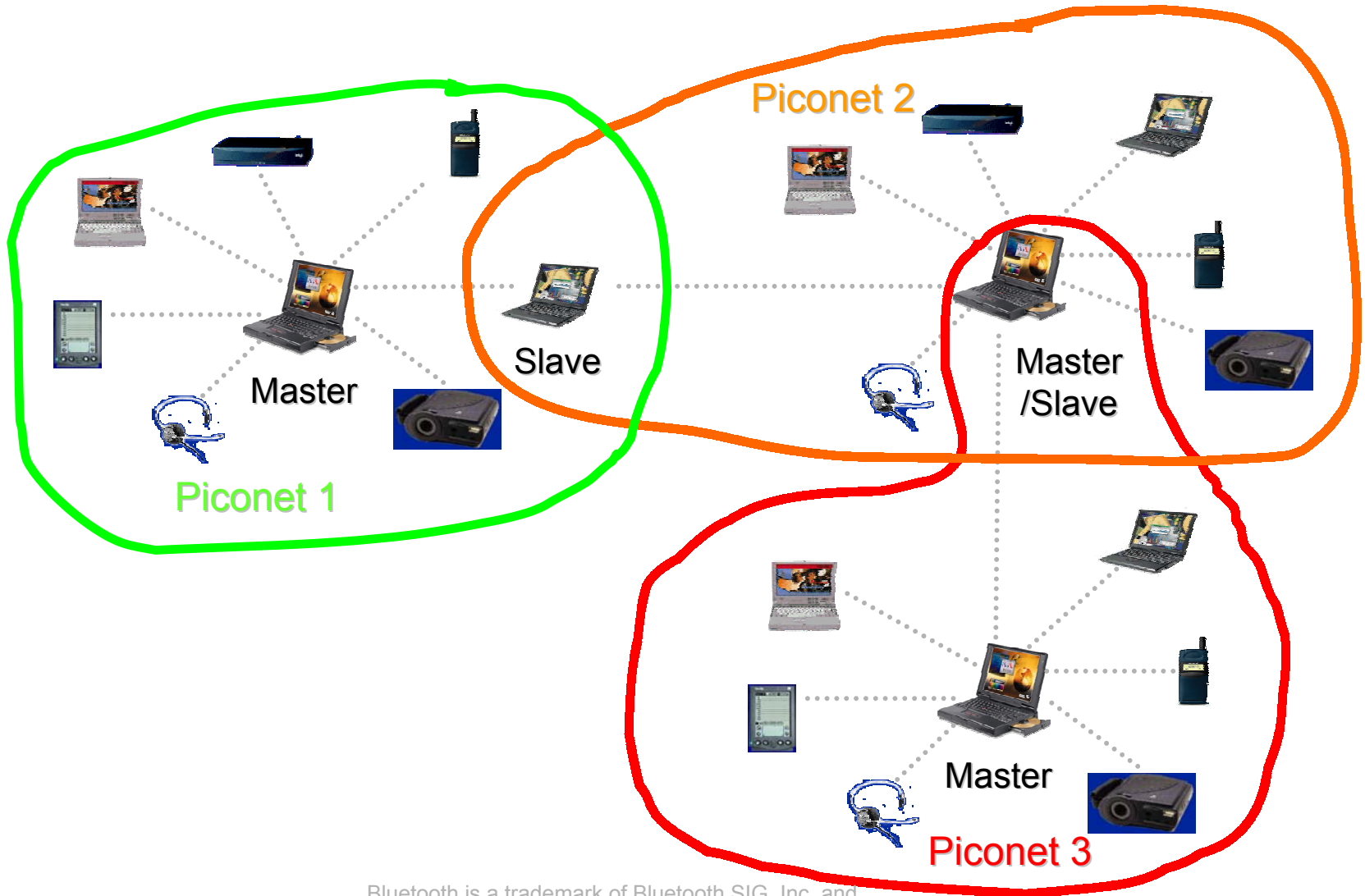
How does Bluetooth™ work?

Piconet



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Scatternet



Bluetooth™ in Perspective

- Bluetooth is:
 - A short range, low power communications scheme
 - A cable replacement
 - A “Personal Bubble”
 - An ad hoc network
- Bluetooth is *NOT*:
 - A full fledged LAN
 - A direct competitor to 802.11

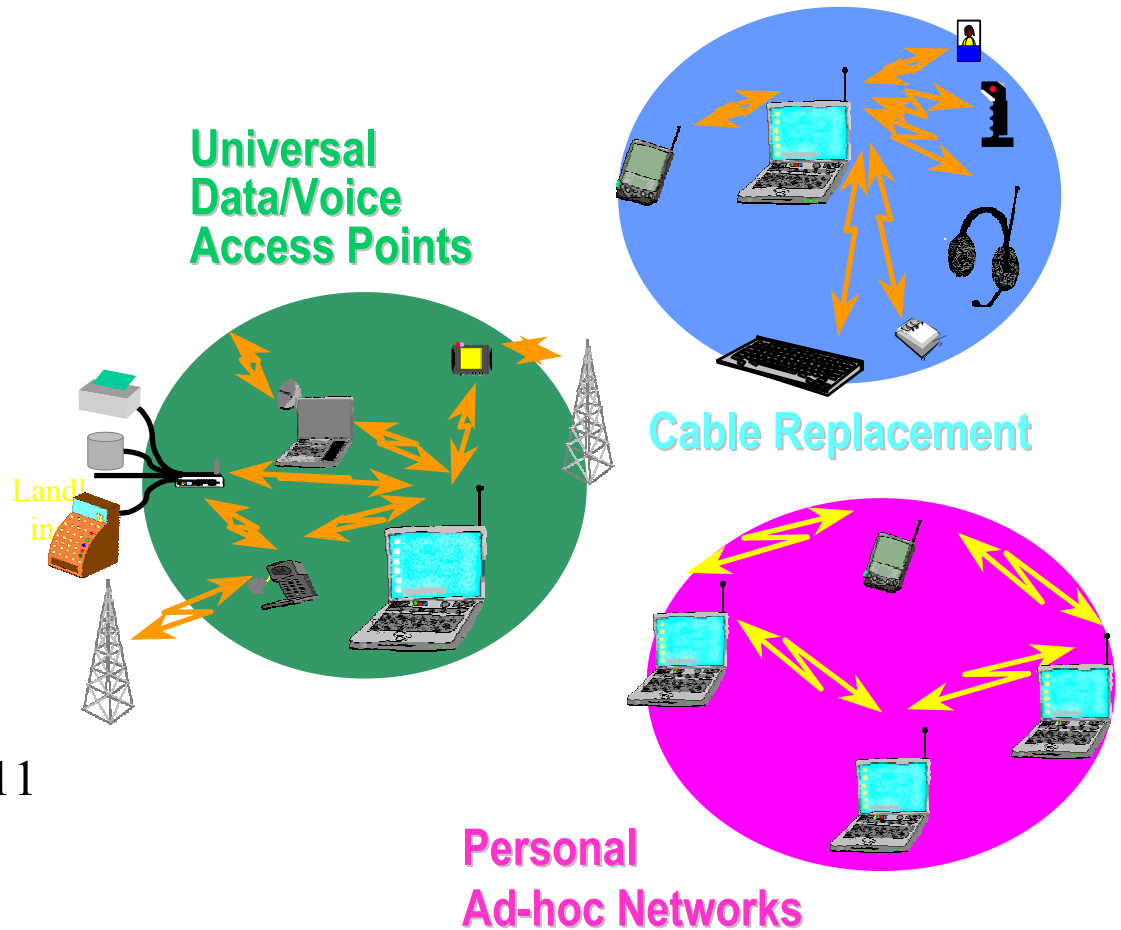


Image source: Intel

Bluetooth Frequency Range

2.4 GHz ISM Band

United States & Europe

Range: 2402 - 2480 MHz
Channels: 79
Channel Width: 1 MHz

Japan, France & Spain

Range: 2471 - 2497 MHz (Japan)
2446.5 - 2483.5 MHz (France)
2445 - 2475 MHz (Spain)
Channels: 23
Channel Width: 1 MHz

Overview of Bluetooth

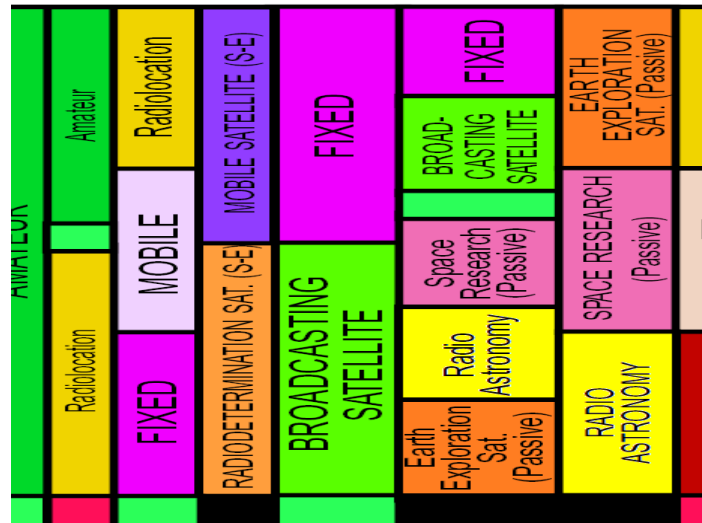
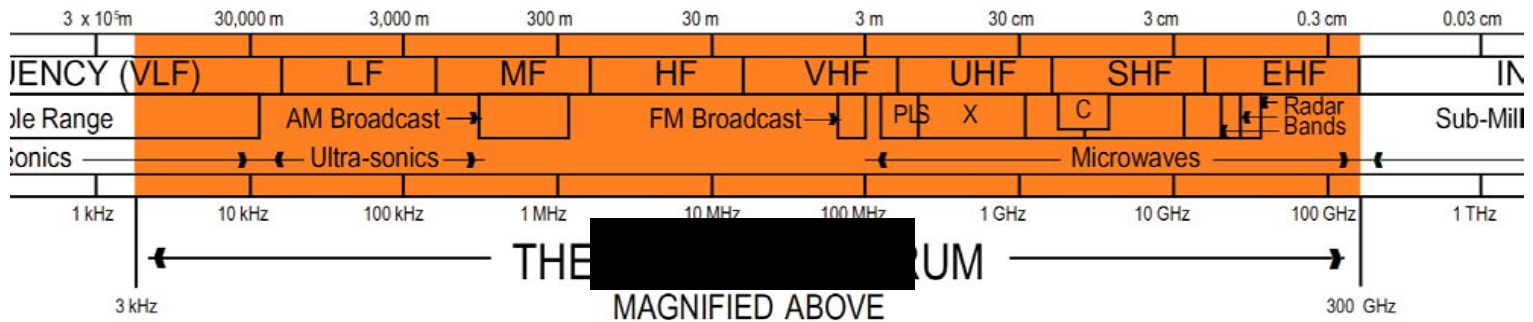
Bluetooth is:

- Short-range radio technology
 - Class 1 (100 m) +20dBm max to 0 dBm w/ power control
 - Class 2 (30 m) + 4 dBm to -6 dBm
 - Class 3 (10 m) 0 dBm max
- Connections without cables
 - Laptops, Cell phones, PDA's, Printers, etc
- Royalty-free
- IEEE Standard through 802.15 (PAN)

Bluetooth Data Links



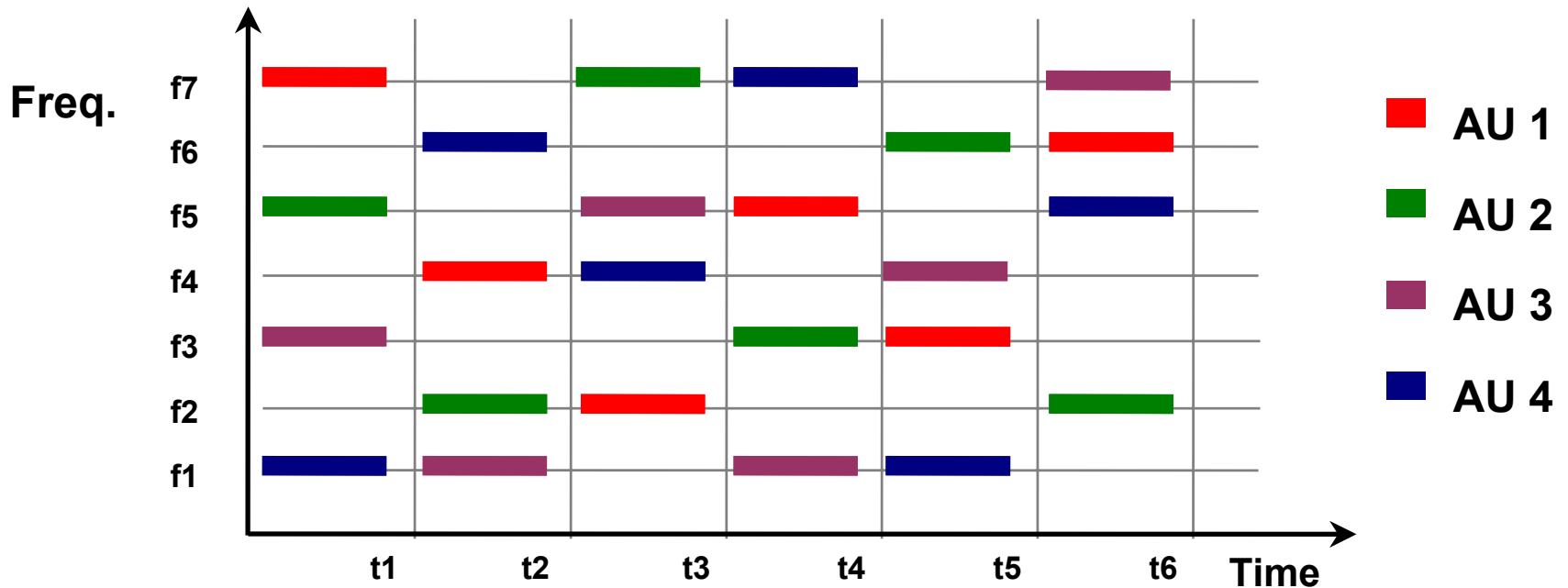
2.4 GHz ISM Band



ISM - 2450.0 ± 50 MHz

Frequency Hopping Spread Spectrum (FHSS)

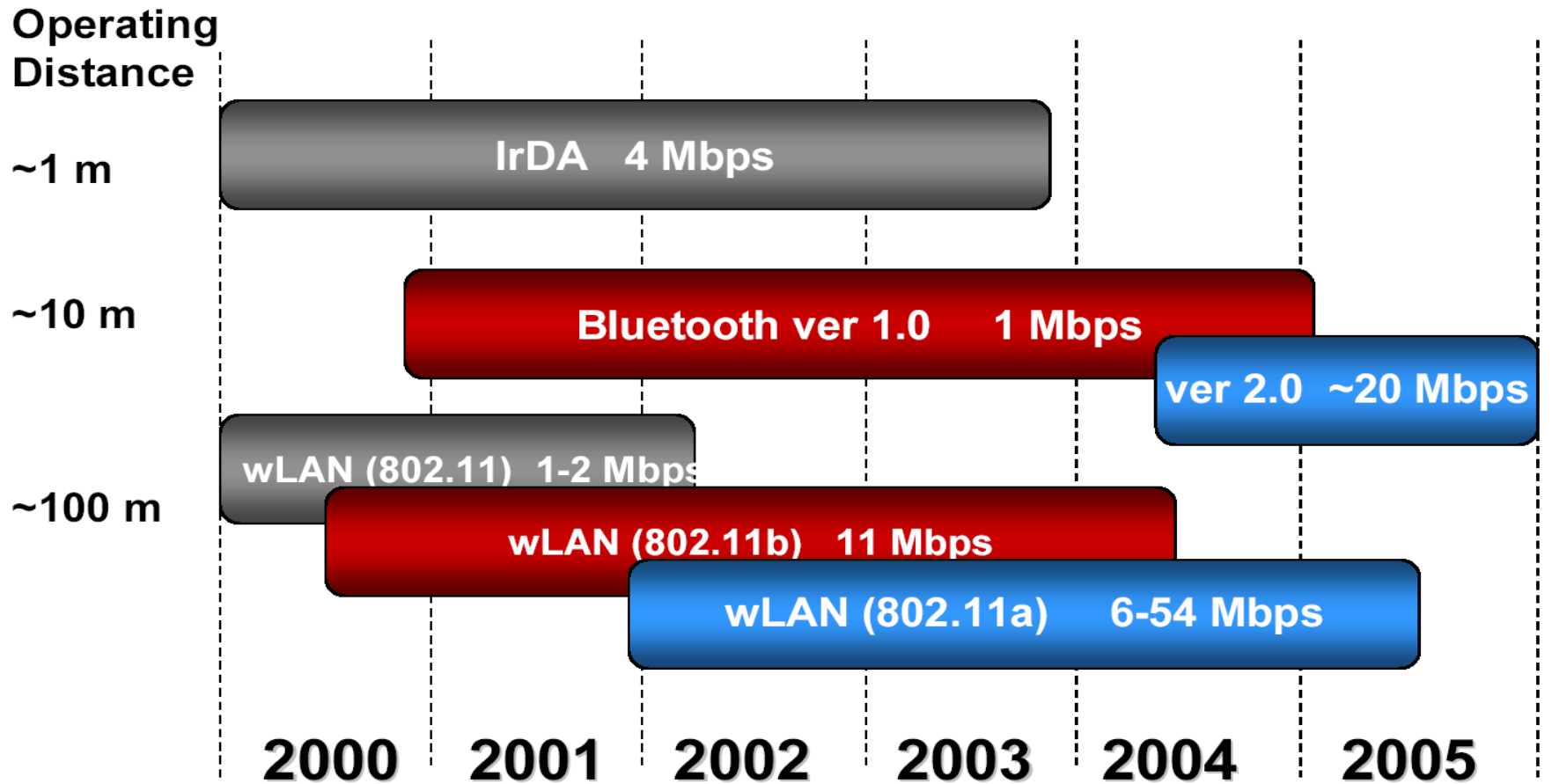
- Transmitted signal is “spread” over a wide range of frequencies (ISM 2.4-2.4835 GHz)
- Transmission hops 8 to 30 times per second



Technology Comparison

	Specification	Strength	Weakness
Bluetooth	2.4 GHz FHSS, 723 kbit/s 10 – 100 meter range	Interoperability. Global standard. Volume gives potentially low cost.	Immature standard and industry.
DECT / DPRS	1.9 GHz, 552 kbit/s 50 – 300 meter range	Mature technology and silicon. Voice/data inter-working.	No world-wide acceptance.
HomeRF	2.4 GHz, 1.6 (10) Mbit/s 30 – 150 meter range	Potentially low cost. Voice/data inter-working.	Only few silicon platforms. Weak support in the industry.
IEEE 802.11b	2.4GHz DSSS, 11 Mbit/s 50 – 100 meter range	Good data rates. Gets more and more acceptance.	High cost. Sensitive to interference. No voice support.
IEEE 802.11a HyperLan2	5 GHz, 54 Mbit/s, 25 – 100 meter range	High data rates. Voice / video.	High cost, high power consumption. Immature silicon.

Wireless Technologies



PANs, LANs and Bluetooth

	802.15.3	802.11 g	802.11 a	Bluetooth 802.15.1	Bluetooth (future)
Band	2.4 GHz	2.4 GHz	5.8 GHz	2.4 GHz	2.4 GHz
Data Rate (Mbps)	<55	TBD	54	1	10
Current Drain (mA)	<80	<350	>350	<80	<80
Number of Video Channels	5	2	5	0	~1
Regulatory					
North America	15.249	Requires Rule Change	15.247	15.249	15.249
Europe	ETSI 300.328				
Japan	RCR-STD-T66 and RCR-STD-33A				
Japan			No Outdoor		
Relative Complexity	1.5X	~3X	4X	1X	TBD
Connect time (seconds)	<1	TBD	TBD	<5	TBD
QoS	New (note 1)	802.11e patched QoS		Limited	TBD
Security	Ad Hoc -Link & Data	WEP/TGi - Server Based		Limited	TBD
Note 1: Modeled 3 video, 1 Internet, 3 phone, one CD audio streams at 33 Mbps mode					
802.11 g is a faster version of the 11 Mbps 802.11b					
General note: BT throughputs do not handle 8 Mbps video w/o compression or reduced video quality.					

Data Rate vs. Range

Unlicensed Spectrum Technologies	Data Rates (per channel)	Max Range [1]	
		indoor [1]	outdoor [2]
2.4 GHz ISM Band			
IEEE 802.11b	1 - 11 Mbps	~300 - 400 ft	2-20+ mi
OpenAir	0.8 - 1.6 Mbps	~300 - 400 ft	3-20+ mi
HomeRF	1-2 Mbps	~100 ft	-
Bluetooth	< 0.5 Mbps	~ 30 ft	-
Proprietary Technologies	~ 1 - 11 Mbps	~100 - 500 ft	2-20+ mi
5 GHz ISM and/or UNII Bands			
IEEE 802.11a	6 - 54 Mbps	~200 ft	35+ mi
HIPERLAN I	24 Mbps	~200 ft	35+ mi
HIPERLAN II	6 - 54 Mbps	~200 ft	35+ mi
HIPERAccess	~20 Mbps	-	-
Proprietary Technologies	6 - 100+ Mbps	-	35+ mi
Free Space Optics	155 - 1000 Mbps	-	0.1 - 1.25 mi
Ultra Wideband (UWB) Radio	20 - 100 Mbps	?	?

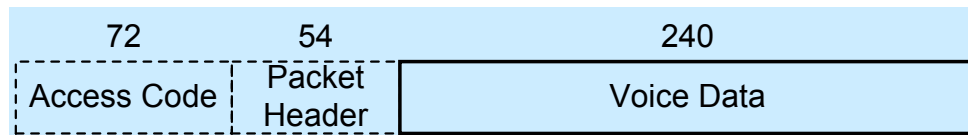
[1] Nominal maximum indoor ranges

[2] Using supplemental antenna systems

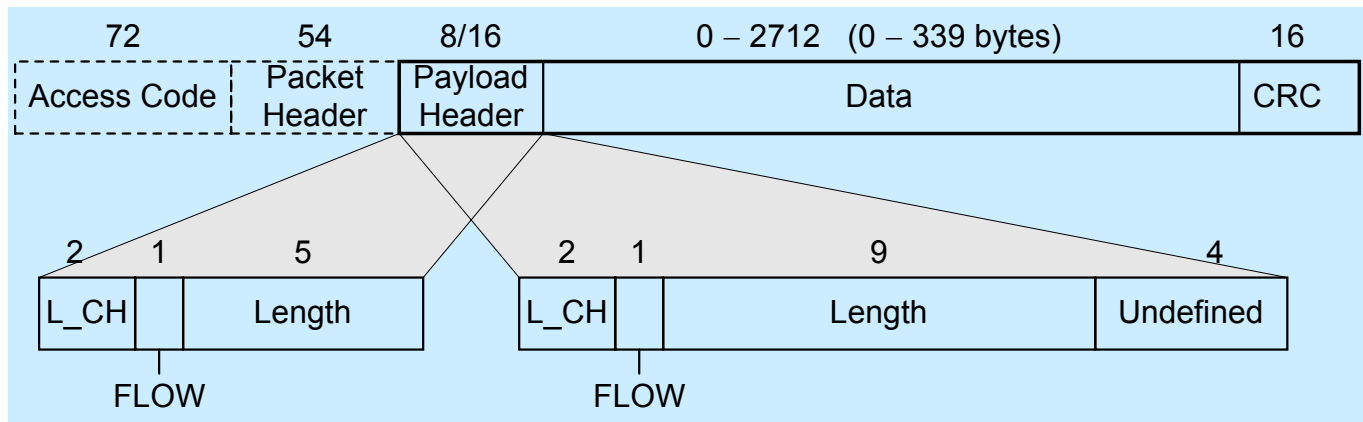
Unlicensed Spectrum Technologies

Payload Format

SCO Packet (HV1, HV2, HV3)



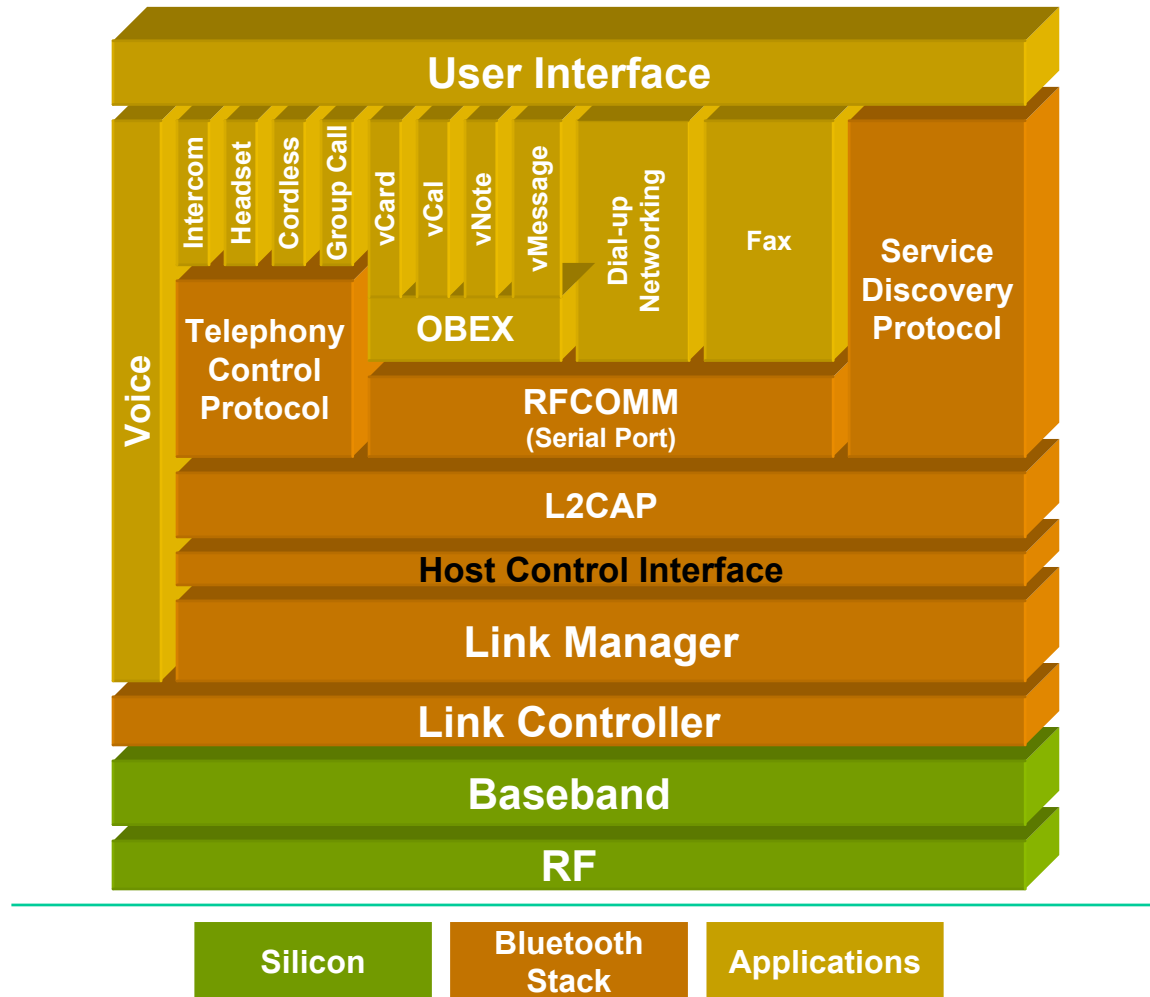
ACL Packet (DM1, DH1, DM3, DH3, DM5, DH5)



L_CH

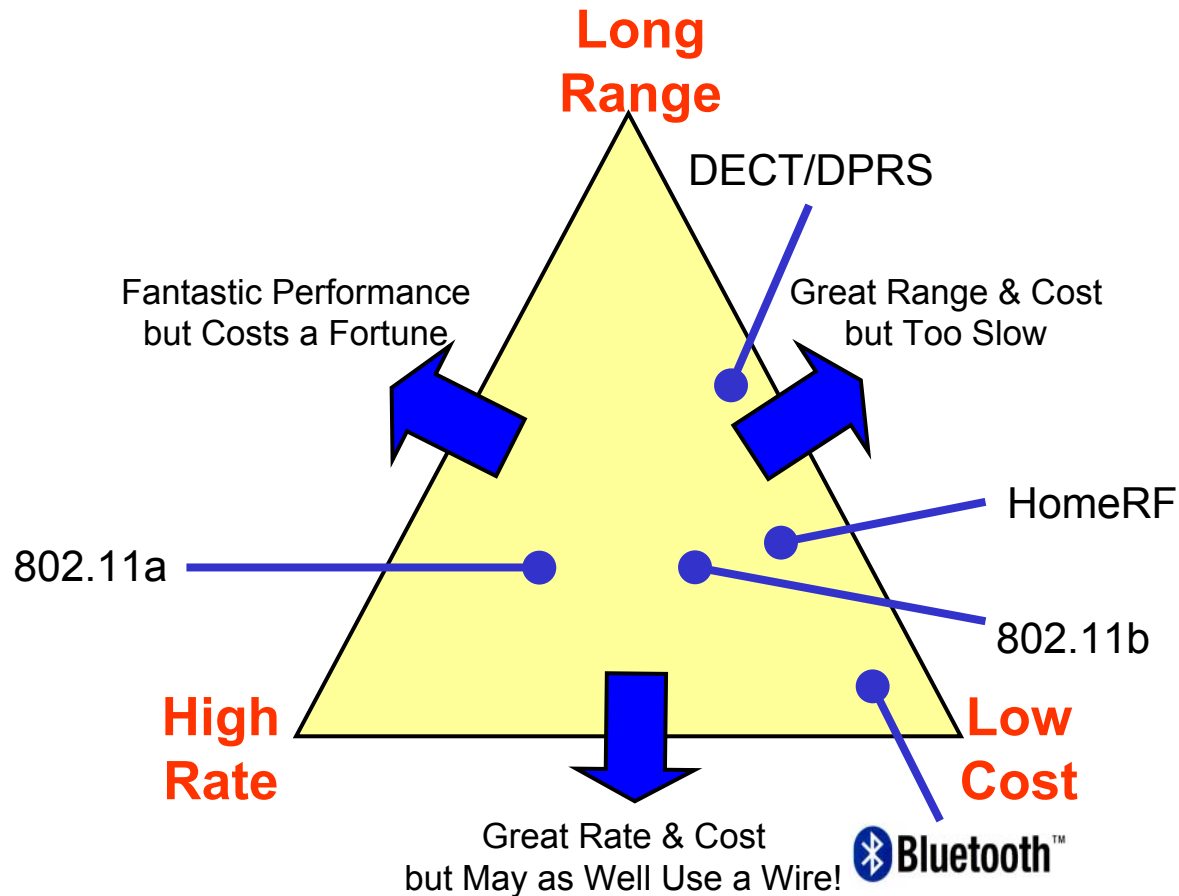
- 01 Continuation of L2CAP message
- 10 Start of L2CAP message or no fragmentation
- 11 Link Manager Protocol (LMP) message

Fully Embedded Bluetooth™

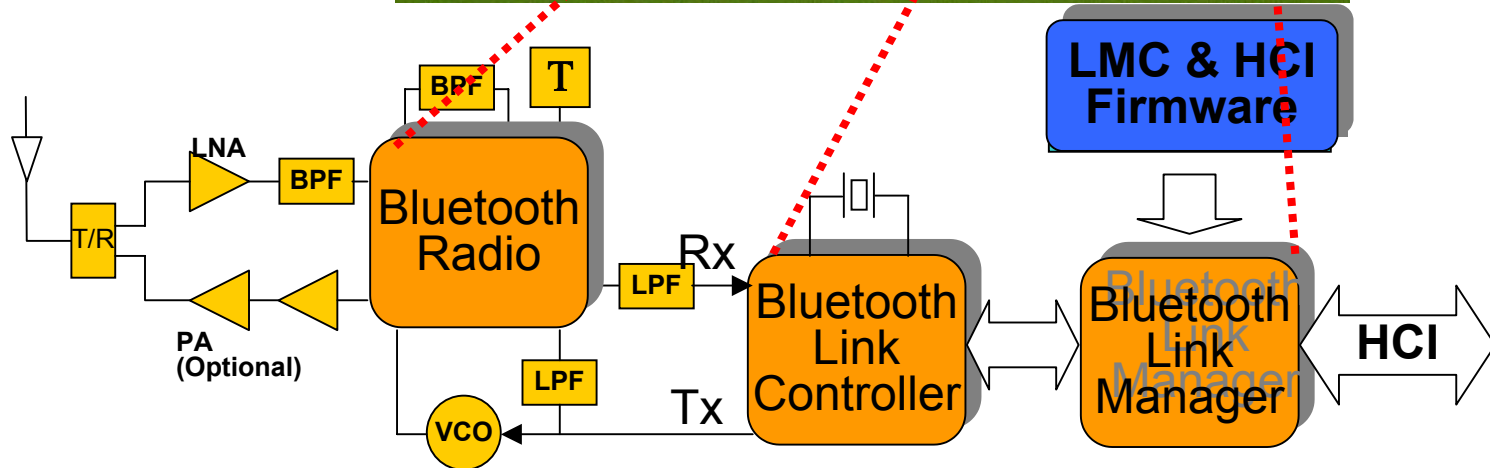
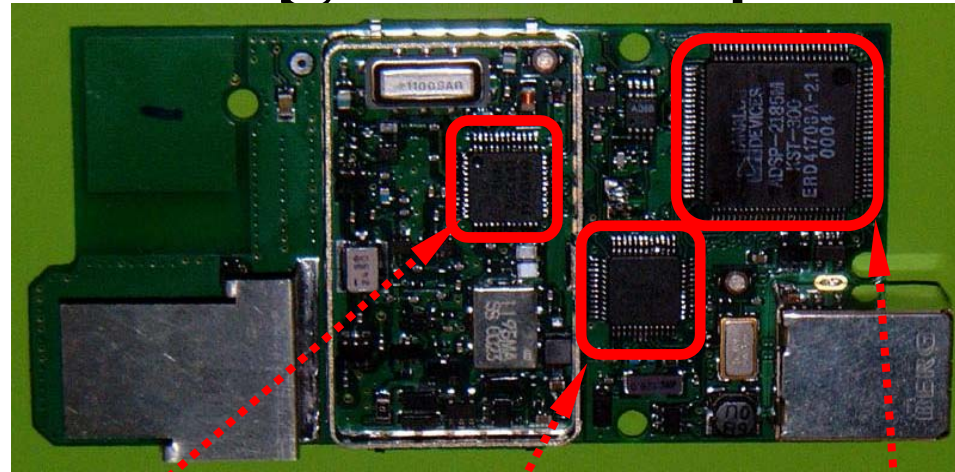


Cost of Implementation

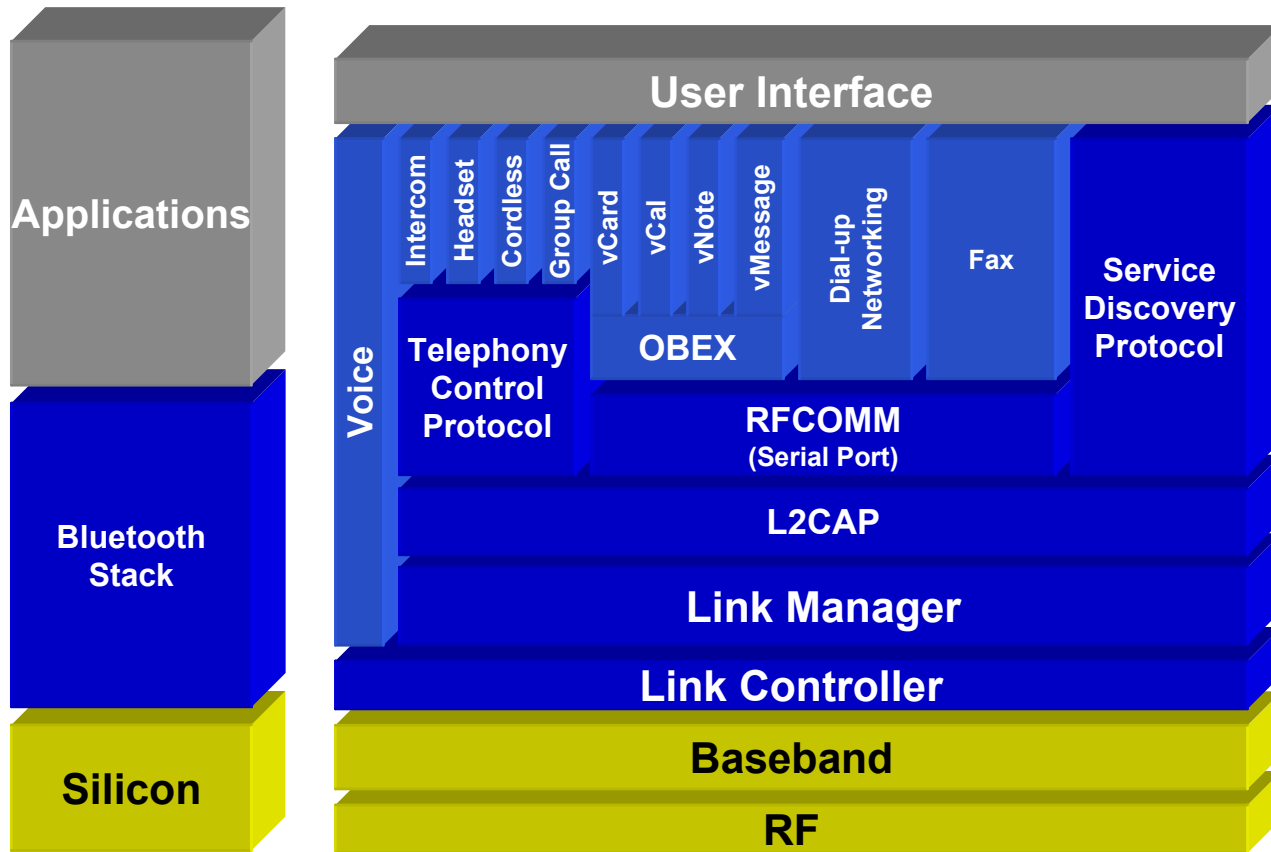
Wireless Technology Tradeoffs



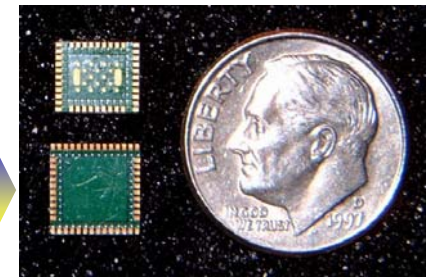
USB Dongle Example



Embedding Bluetooth

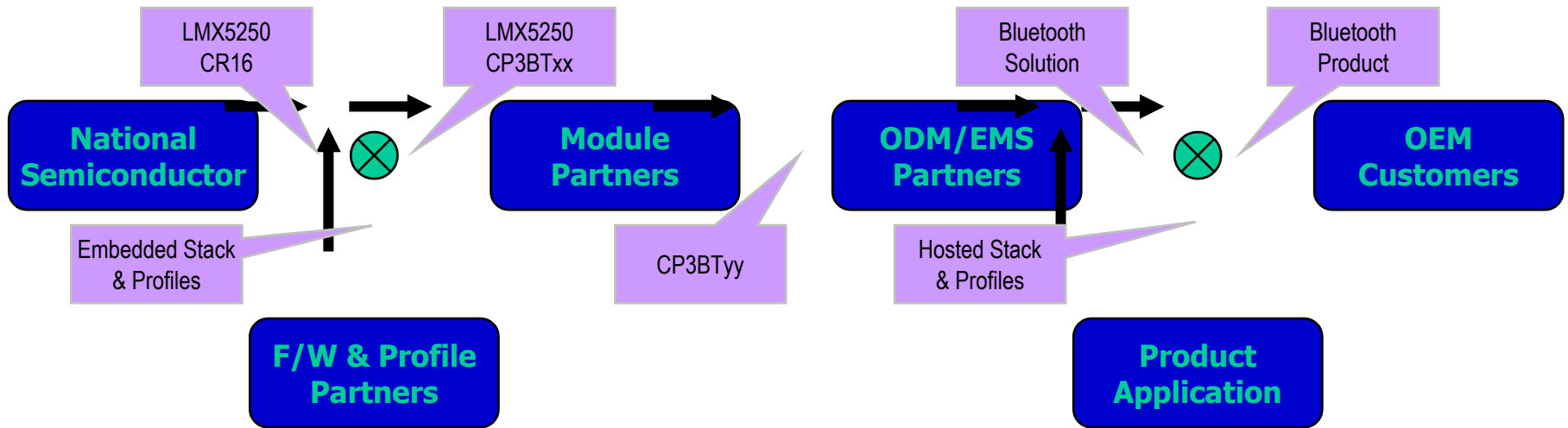


Far more than just Bluetooth Functions...



- Integrates application functions utilizing microcontroller core and on-chip μ C peripherals
- Bluetooth functionality through defined API
 - Little Bluetooth expertise necessary
- Eliminates separate host / system controller
 - Reduces Cost
 - Reduces Board Space

Bluetooth Success



Consumers

→ Guarantee Ease of use for Transparent Functionality

OEMs

→ Provide End to End Solution through Bundling of Products

ODMs

→ Create New Products from Qualified Reference Designs

Stack Providers

→ Supply Memory Efficient, Well-documented Qualified Stack, Profiles and Examples

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Success in the Bluetooth chain has different meanings based on your viewpoint...

Risk of Implementation

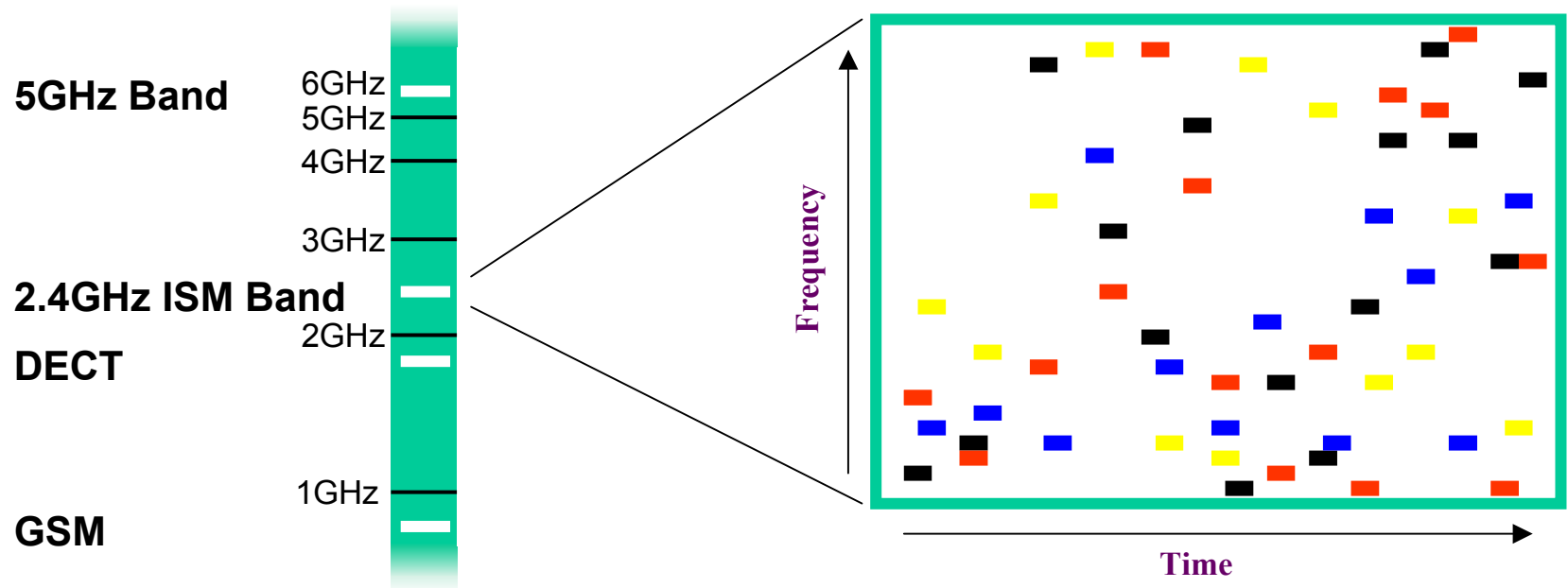
2.4 GHz ISM FHSS

Frequency & Modulation

Parameters		Bluetooth	HomeRF	Upbanded DECT	
Frequency					
Band		2.402 - 2.480 GHz	2.404 - 2.478 GHz	2.40 –2.483 GHz	
Channel Spacing		1.000 MHz	1.000 MHz	≥ 1.000 MHz	
Accuracy		± 75 kHz	± 120 kHz	± 50 kHz	
Lock time (est)		220 μsec	134 μsec	30 μsec (416.67 usec w/1 Blind slot)	
Drift		± 40 kHz/ 5 slots	NA	± 40kHz/msec	
Modulation					
Type		GFSK	2-FSK	(4-FSK)	GFSK
Deviation	Min	± 140 kHz	± 85 kHz	± 135 kHz	± 200 kHz nom. (± 250 kHz nom)
	Max	± 175 kHz	± 177.5 kHz	± 190 kHz	
Burst Bit Rate		1 Mbits/s	1 Mbit/s	2Mbit/s	1.152Mbits/s (1.0Mbits/s)
Accuracy		+/- 20ppm	+/- 50 ppm	+/- 9 ppm	N/A

2.4 GHz ISM Band Traffic

- 2.4 GHz (ISM band) is an unregulated band
- The ISM band carries a lot of traffic: WDCT, HomeRF, IEEE802.11b, Microwave ovens, other communication systems, etc.



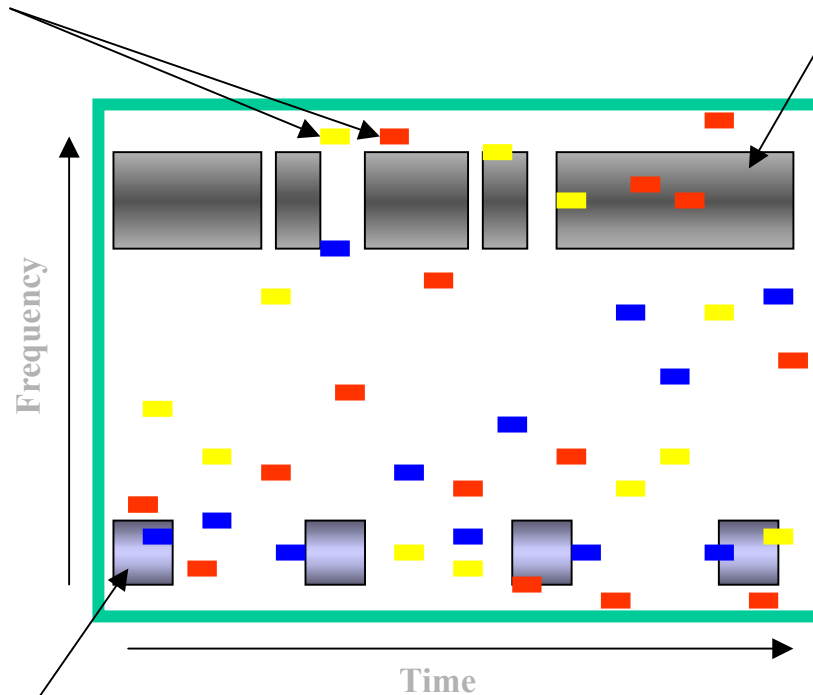
BT Interference Challenge

FHSS based standards

- Bluetooth
- DECT @ 2.4GHz
- HomeRF

DSSS based standards

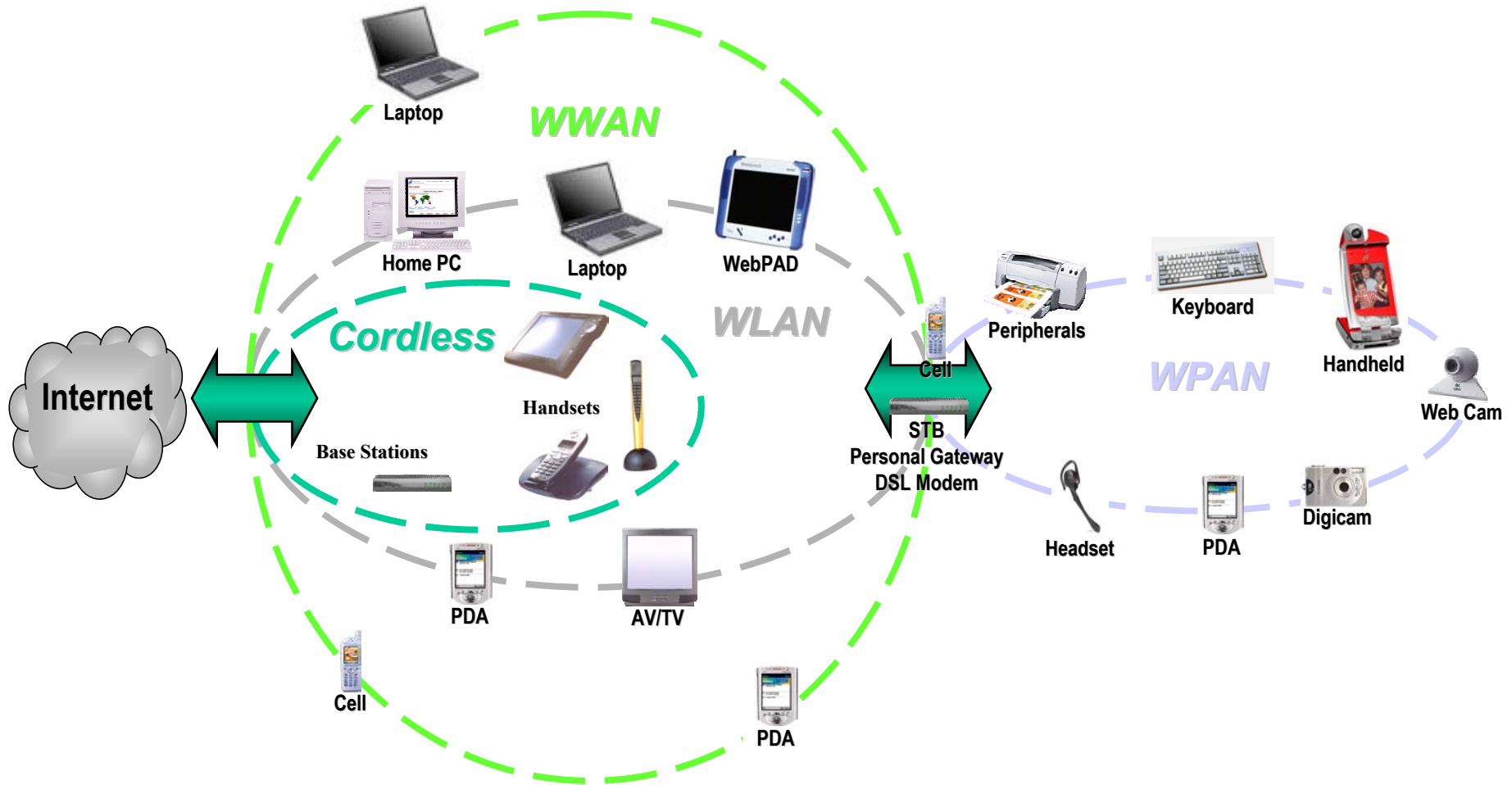
- IEEE 802.11b



Microwave ovens

Benefits

Benefits of Interoperability



Appendix

Acronyms

ACL	Asynchronous Connection-Less (link)
CRC	Cyclic Redundancy Check
CVSD	Continuous Variable Slope Delta modulation
FEC	Forward Error Correction
HCI	Host Controller Interface
LC	Link Controller
LM	Link Manager
L2CAP	Logical Link Control and Adaptation Protocol
PCM	Pulse Code Modulation
RFCOMM	Protocol used for serial port emulation
SCO	Synchronous Connection-Oriented (link)
SDP	Service Discovery Protocol
UART	Universal Asynchronous Receiver-Transmitter
USB	Universal Serial Bus



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