WF102:
Choosing a Wireless Solution

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Making Wireless M2M Easy

Agenda

- Design questions
- Chip vs. Module
- Module integration
- Protocol options
- Questions

Design Questions

- How much range do you need?
- What maximum required bandwidth?
- Where will the solution be deployed and under what conditions?
- Will the design be battery powered?
- How often does data need to be transmitted?
- What parameters are flexible and open to design tradeoffs?

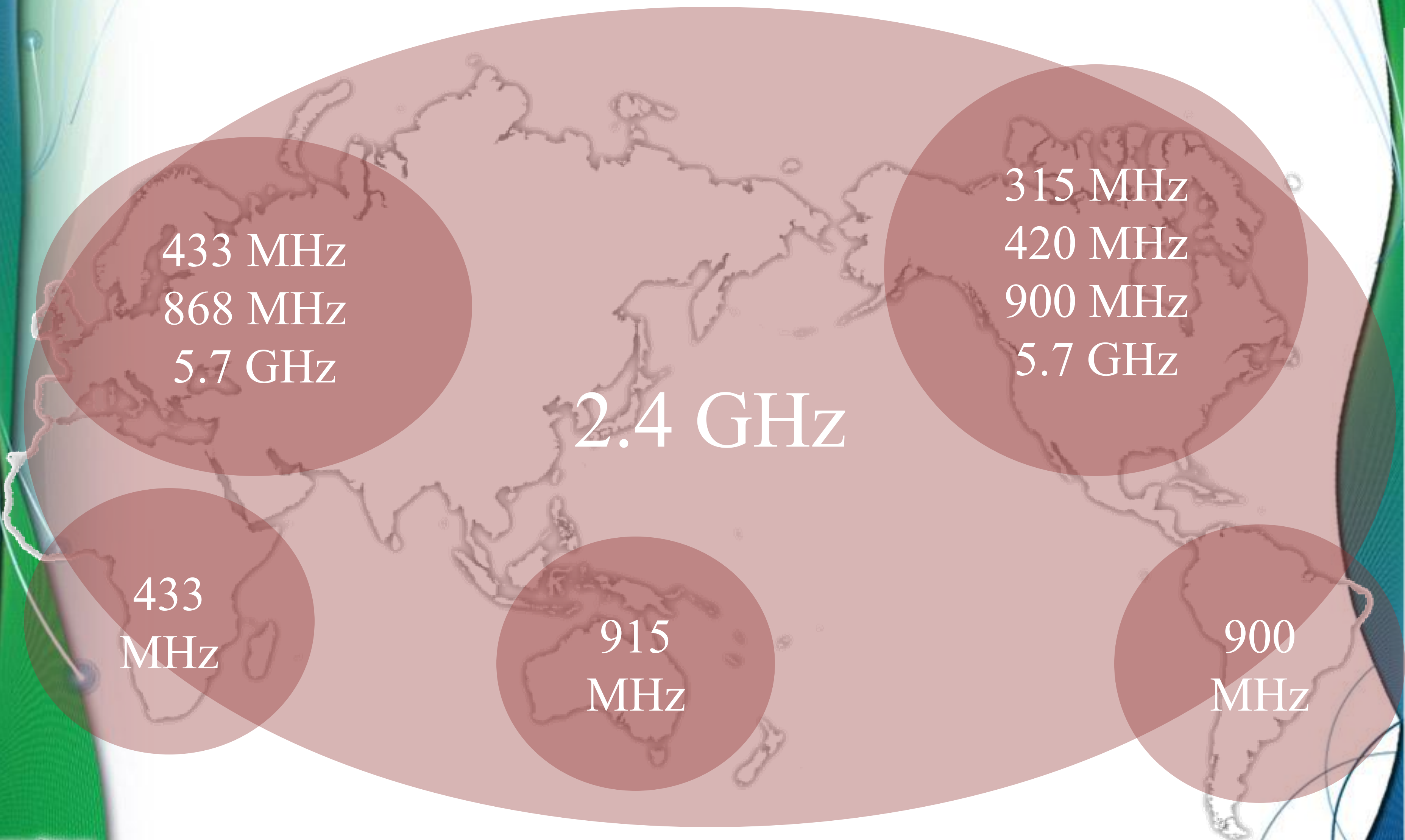
Design Questions

- How much range do you need?
  - Frequency considerations
  - Environmental considerations
  - Output power in Europe ~10dBm (10mW)
  - For 0 dBm – 30m indoor, 100m outdoor
  - For 10dBm w/ LNA – 60m indoor, 1km outdoor
- What maximum required bandwidth?
  - 250 kbps over the air, but 125 kbps *max*
  - 38.8 kbps more typical for PtP and PtMP networks
  - Slower for mesh technologies

Importance of Frequency Selection

- Where will the solution be deployed and under what conditions?
- Geographic deployment
  - Worldwide vs. Regional
  - Cost considerations
- RF performance
  - Range
  - RF penetration
  - Antenna considerations

License-Free Bands



Regulatory Bodies

- FCC (United States)
- IC (Canada)
- ETSI (Europe, some APAC)
- C-Tick (Australia)
- Telec (Japan)
- Anatel (Brazil)

Design Questions

- How often is data transmitted?
  - Affects sleep mode and battery life
  - Determining factor in whether or not mesh can be used

Design Questions

- Battery life calculation example

Current in TX (mA)	40	**Alkaline AA**	
Current in RX (mA)	45	Batterylife (hours)	30551.63
Sleep current (mA)	0.035	days	1272.984
Time interval (min)	60	years	3.487629
time in TX (ms)	3000		
Time in RX (ms)	2000	**Lithium**	
		Batterylife (hours)	32159.61
% Duty Cycle in TX	0.08%	days	1339.984
% Duty Cycle in RX	0.06%	years	3.671188
% Duty Cycle in sleep	99.86%		
Avg current draw	0.093285	**Alkaline D**	
		Batterylife (hours)	128638.4
		days	5359.934
Battery Capacities		years	14.68475
AA Alkaline mAh	2850		
AA NiMH	2500		
Lithium	3000		
D Cell Alkaline (typ)	12000		

Design Questions

- What parameters are flexible and open to design tradeoffs?
  - Battery Life vs. Data Rate
  - Battery Life vs. Data Frequency
  - To Mesh or Not to Mesh
  - Placement vs. Range
  - Frequency vs. Homogenous SKUs

Design Questions

- General Considerations
  - Power supply (voltage, current)
  - Battery types
  - Antenna placement/enclosures
  - Data format (transparent/API)
  - Data backhaul or local network?
  - Network topology

RF Development

Components

- Time (development time – opportunity costs)
- Hardware and expertise
  - Development hardware (spectrum analyzer, etc.)
  - RF engineers, antenna design
- Test fixture design
- Certifications

RF Development Timeline & Expense Overview for a ZigBee solution

1. Timeline Risks (22 - 32 weeks, assuming no major redesigns and all certs pass on first round)

a. Hardware development (12 – 19 weeks total)
b. Software development (22 – 32 weeks total)
c. Test fixture development (12 – 20 weeks)

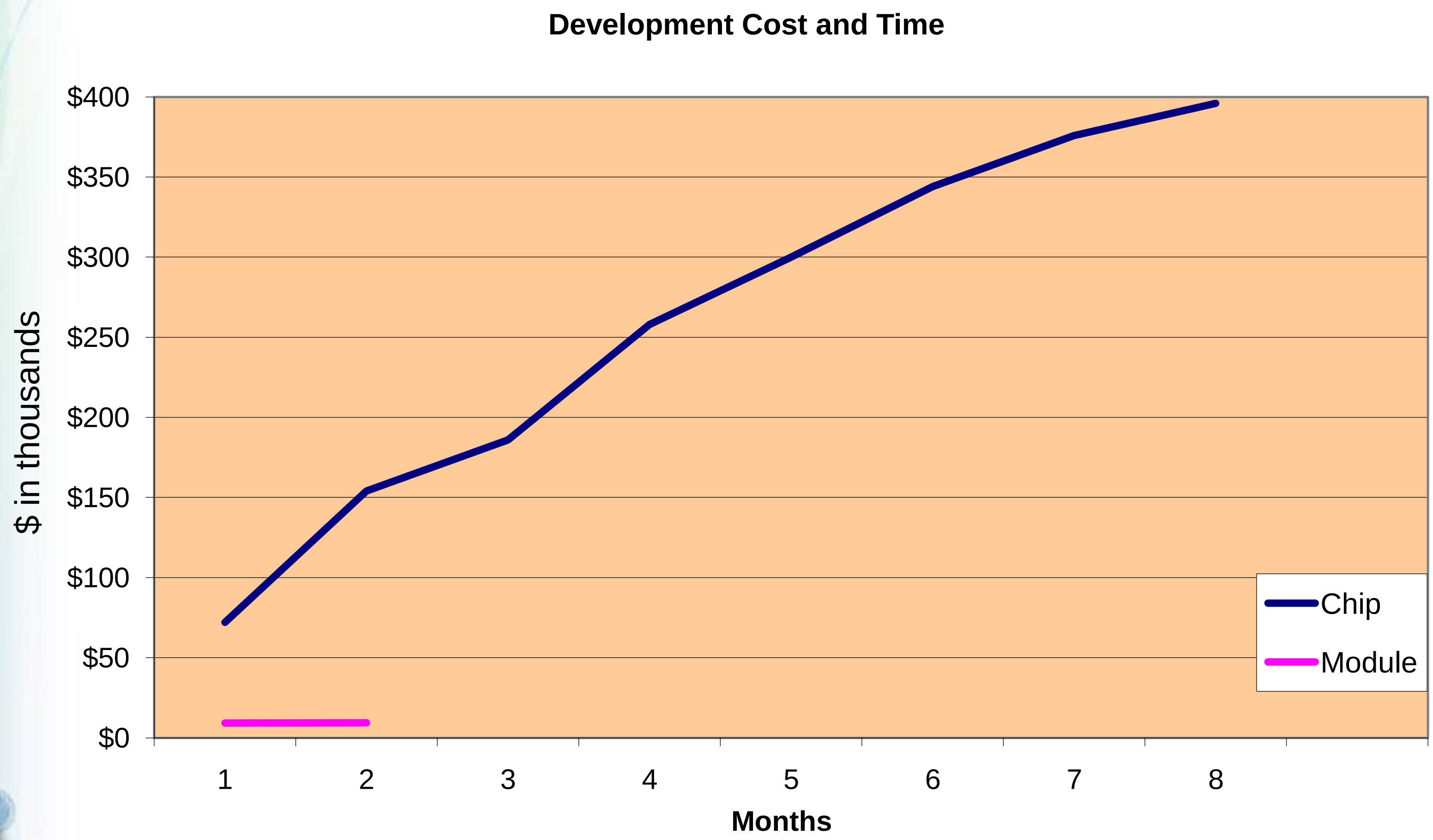
2. Development Expense ($349,500 - $572,500, assuming no major redesigns, all certs pass on first round and excludes opportunity cost)

a. Tools – $99,500 - $225,500 total
   i. Compiler & tools – $2,500
   ii. Spectrum analyzer – $45,000 - $90,000 (could be leased)
   iii. Network analyzer – $45,000 - $90,000 (could be leased)
   iv. Testing software – $3,000 - $5,000
   v. SE/Certicom tools 7 licenses – $30,000 Annually
   vi. SE test harness – $4,000 - $8,000
b. Engineering time –$126,000 – $191,00 total
   i. Hardware – $60,000 (12 wks @ $5K/wk) - $95,000 (19 wks@ 5K/wk)
   ii. Software – $66,000 (22 wks @ $3K/wk) - $96,000 (32 wks@ 3K/wk)
c. Certification – $20,000
   i. Worldwide certifications $20,000 every two-to-three years (recertify as major components rev)
d. Test Fixture – $104,000 - $136,000
   i. Hardware – $60,000 (12 wks @ $5K/wk) - $100,000 (20 wks@ $5K/wk)
   ii. Software – $24,000 (8 wks @ $3K/wk) - $36,000 (12 wks @$3K/wk)

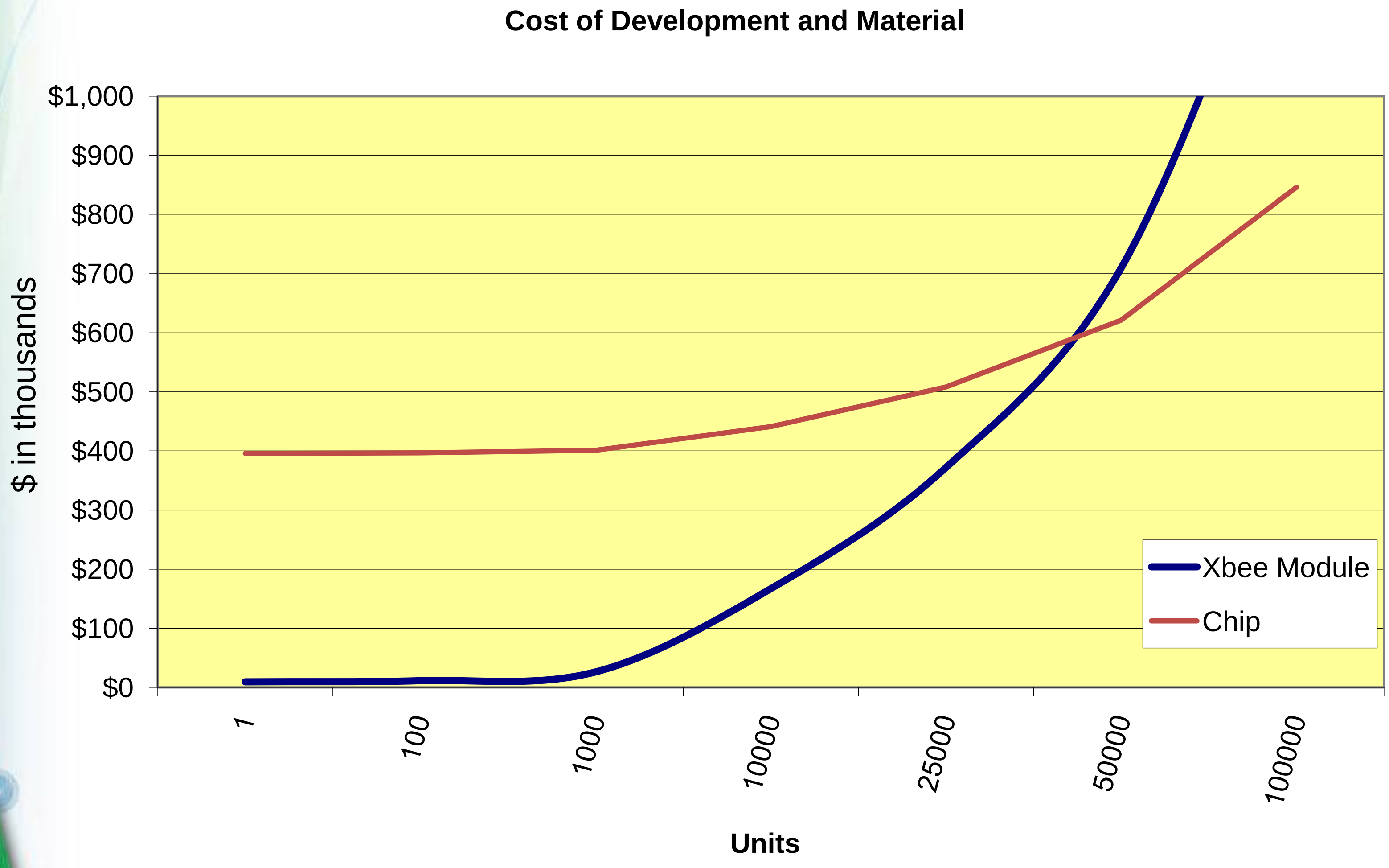
Assumptions:

1. Timeline assumes developers have equal RF experience as Digi RF engineers.
2. Timeline assumes developers have considerable ZigBee Smart Energy expertise.
3. Timeline assumes development is done in parallel by multiple assets (e.g. there are independent teams for Test Fixture Hardware, and Test Fixture Software).
4. Tool needs assume all fundamental RF Design & Test tools must be acquired/developed.
5. Engineering Time expenses assume cost for single engineer + overhead for given period.
6. No significant design challenges—a poorly designed board could add another 3 months in design time to pass FCC certification; getting calibration right between a thermostat product, a different load controller, and a smart meter could add another month. In our own experience,

Chip vs. Module - TTM

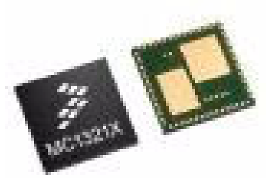


Chip vs Module…cost



Chips and Modules

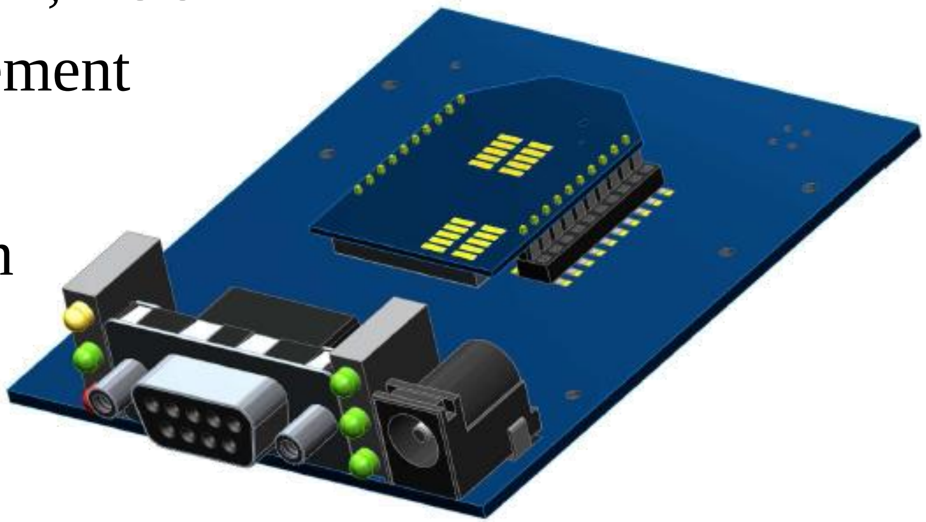
- Chip Advantages
  - Size
  - Customization
  - It's mine!
  - Cost (large volumes)
- Disadvantages
  - Certification
  - Chip & design re-spins



- Module Advantages
  - Ease of integration (time-to-market)
  - Certifications
  - One design may support multiple topologies
  - Managed hardware changes
  - Cost (other volumes)

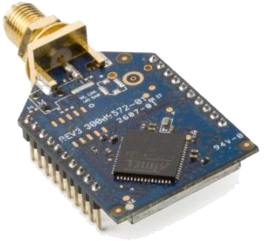
Module Integration

- Typical hardware features and issues
  - 3.3V UART interface
  - Requires only
    - VCC, GND, DIN, DOUT
  - Component placement
  - Packaging
  - Antenna selection



Module Integration

- Antennas
  - Chip Antennas
    - Best mechanically
    - Lowest range
  - Wire Antenna
    - ¼ wave 1.8 dBi gain
    - Used w/ Plastic/fiberglass enclosures
  - RPSMA
    - Connects to external dipole
  - U.FL



Module Integration

Antennas

Module Integration

Antennas

Wireless Choices

ZigBee

Bluetooth

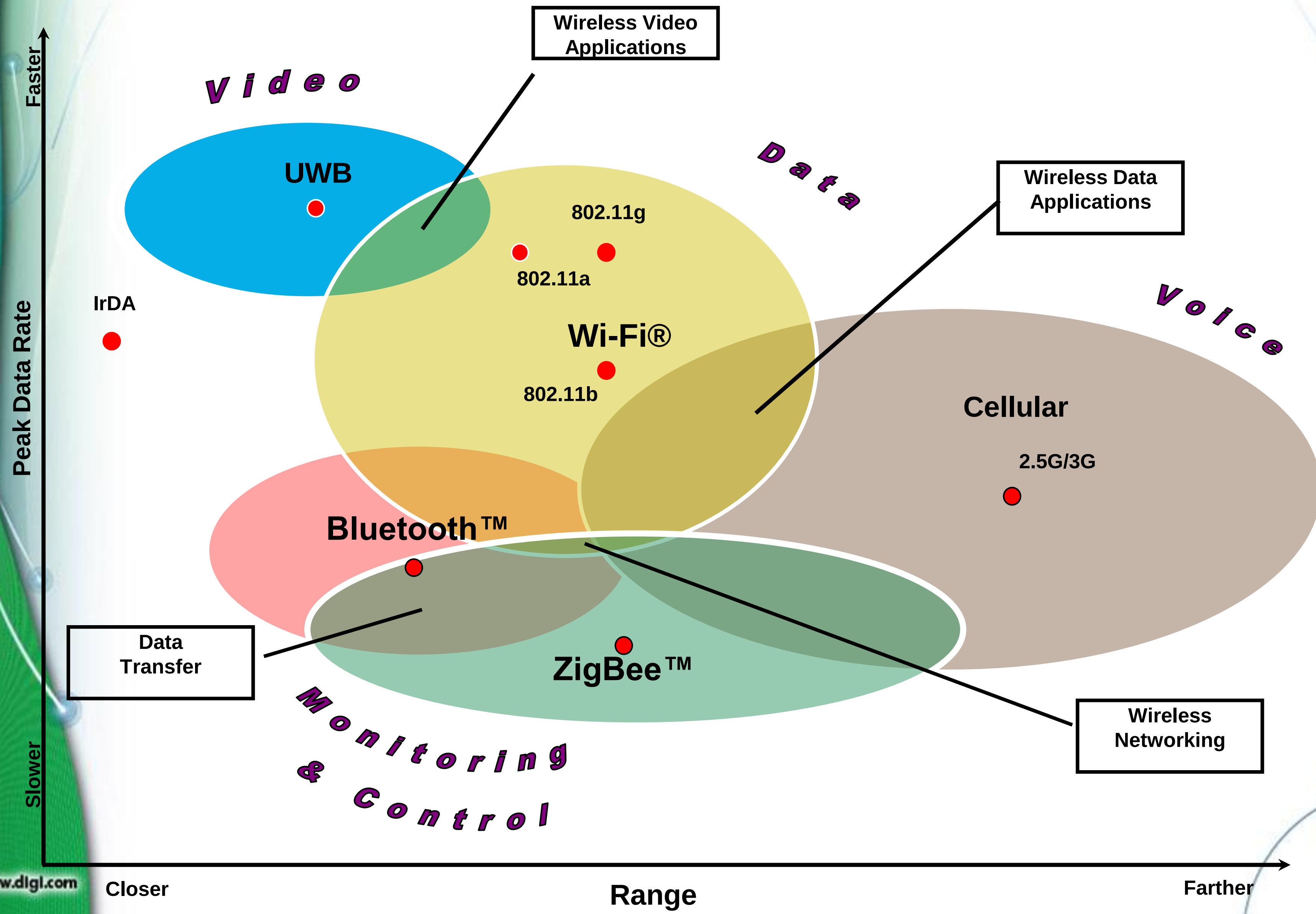
UWB

Wi-Fi

Cellular

6LoWPAN

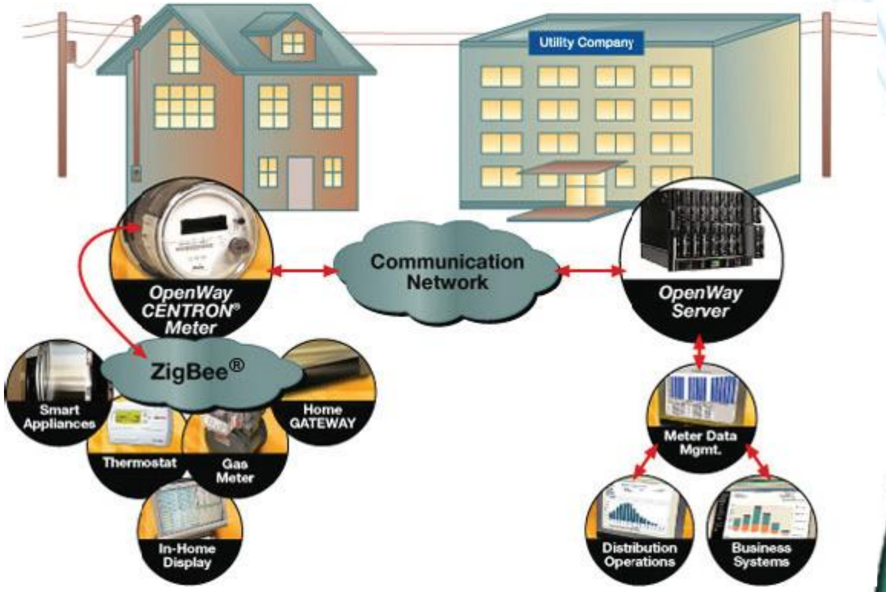
Rates and Ranges



Wireless Standards Comparison

Feature(s)	IEEE 802.11b	Bluetooth	ZigBee
Battery Life	Hours	Days	Years
Complexity	Very complex	Complex	Simple
Nodes/Master	32	7	64000
Latency	Enumeration up to 3 seconds	Enumeration up to 10 seconds	Enumeration up to 30 milliseconds
Range	100m-1000m	10m	70m-1600m
Extendability	Roaming possible	No	Yes
RF Data Rate	11Mbps	1Mbps	250Kbps
Security	Authentication Service Set ID (SSID)	64-bit, 128-bit	128-bit AES and application layer user defined

ZigBee



- Low cost
- Low power
- Security-enabled
- Reliable
- Initial target markets were AMR, building automation, and industrial automation (M2M Comms)
- Digi is a member of the ZigBee Alliance

Wi-Fi (802.11)

- 2.4 GHz
- Most popular
  - 802.11b = 11 Mbps
  - 802.11g = 54 Mbps
    - backwards compatible with 802.11b
- Range – a few hundred feet (~100 m)
- Can be infrastructure standard

Cellular

- 3G / 2.5G
- Data rates – in the few hundred kbps range and below
- Costs, carrier fees
  - ~$.10-.50 per MB
  - ~$50-60 per month unlimited

Conclusion

- Ways to judge wireless options
  - Frequency
  - Range
  - Throughput
  - Costs
  - Interference
  - Power requirements
  - Features