6 Things You Need to Know to Design Wireless Products

Chase Sebor

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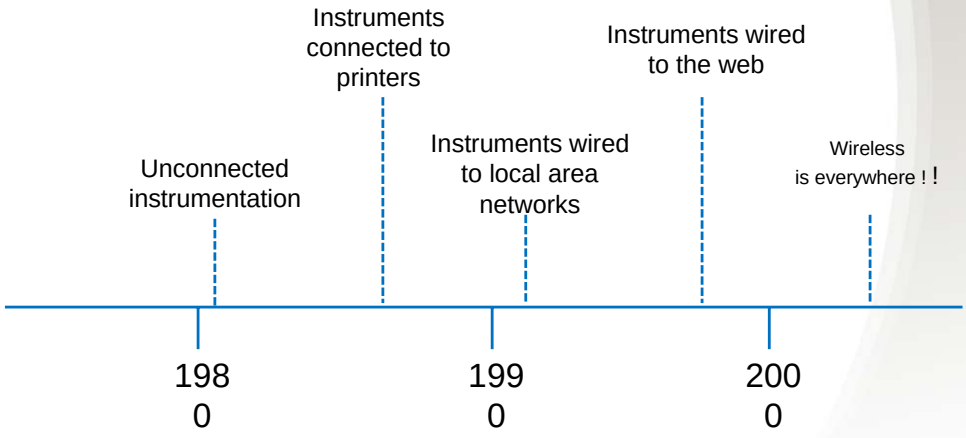
Introduction

Who is Venture Technologies Inc.?

- A Boston-based product development and engineering services company.
- We develop products that measure, control, analyze and communicate.

We license a wireless communications solution called RFOS

The RF Timeline for design of instrumentation



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Example of RF is everywhere

Venture is currently designing a product with three kinds of wireless inside

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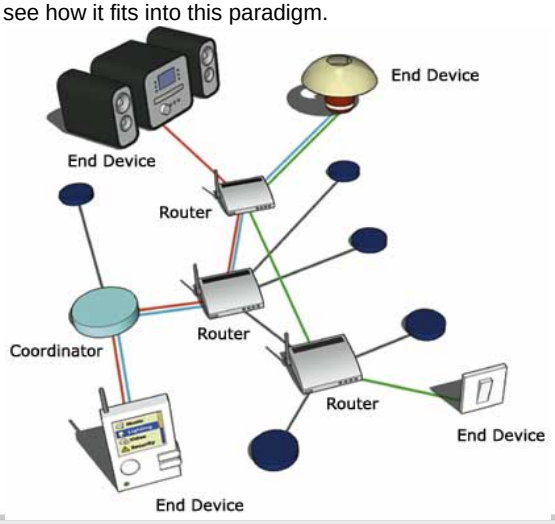
GPS location - CellPhone communication – RFID reader

What will wireless mean to your product?

- Will it be more reliable, less reliable, or just more-or-less reliable?
- It can accomplish more, but can it accomplish everything marketing envisions?
- It's a new paradigm, and you need to understand how your product needs to function to see how it fits into this paradigm.



Questions to ask yourself or your customer

1. What data are you transmitting?
2. What is your network topology?
3. Is battery life an issue?
4. How important is setup / security?
5. What is your target cost & volume?
6. Do I need standard or custom?

What data are you transmitting?

- Amount of data
- Packaging
- Data direction
- Starting and stopping the transmission

What data are you transmitting?

Amount of Data

- **Small**
  Sensor data input or device control output

- **Medium**
  Still images or streaming audio

- **Large**
  High quality streaming audio or video

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What data are you transmitting?

Packaging

- Packets

or

- Streaming

What data are you transmitting?

Direction

- One way

- Bidirectional

- Acknowledgement

What data are you transmitting?

Starting and Stopping the transmission

- Who initiates?

  To minimize battery life, let remote sensors wake up and initiate communication, as central units can often be line powered and always listening.

  If reconfiguration, calibration, or alarm notice needs to be driven out to remotes, let the central unit initiate communication. Design remote units to respond or to receive only as often as they ever have to, to maximize battery life.

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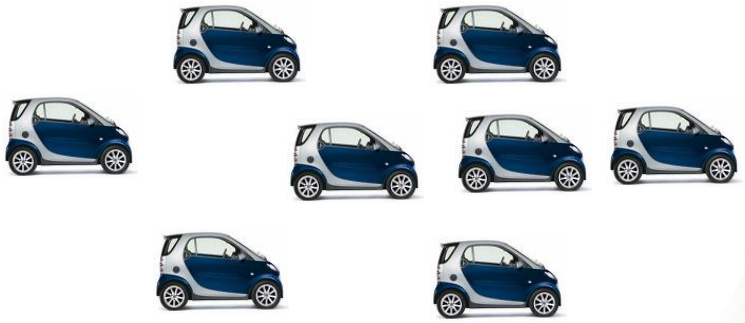
What is your network topology?

- How many units in the wireless network?
- Do nodes in the network come and go?



What is your network topology?

How many units?

- 2 units (point to point)

- Multiple units
  - Do the units need to talk to each other or just a central point?
  - Is every unit close enough to communicate directly with the units it needs to?

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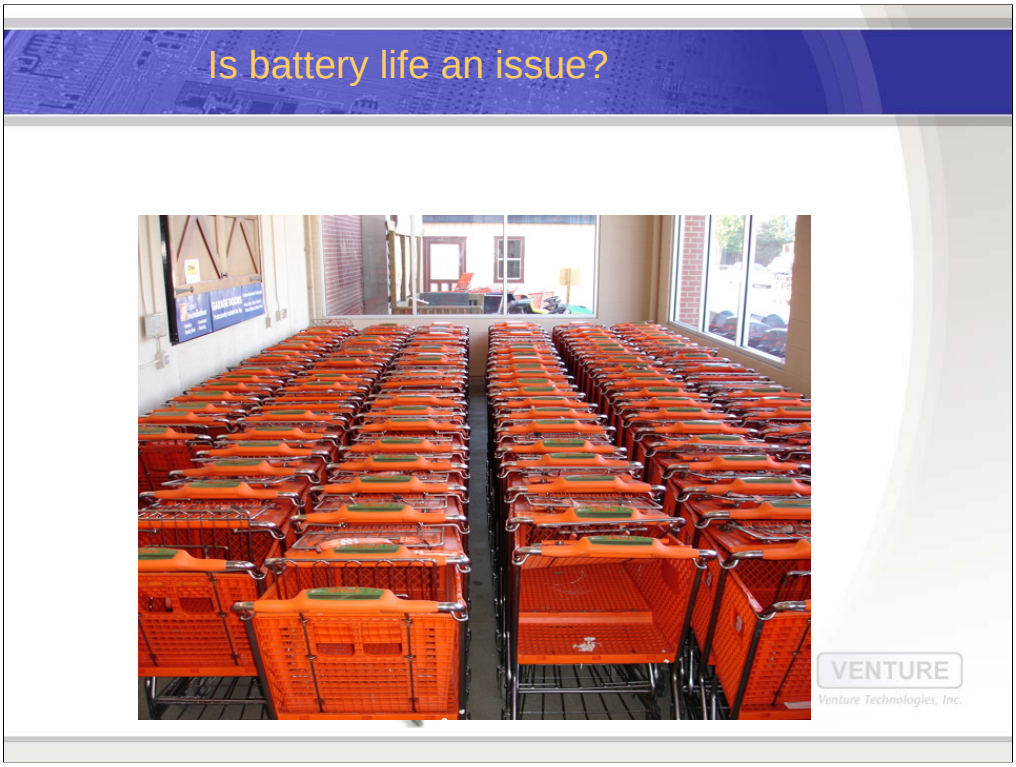

3. Battery life

Sleep

Picture: Single shopping cart

The wireless shopping cart advertising system needed five years of battery life. We use a micro that sleeps at a very low current drain, and only communicates several times a day.

Maintaining synchronization:

Picture: Dog training system

The dog trainer products changes frequencies in tandem, a technique called frequency hopping. We sync clocks, then sleep, and wake up at a precise time, with transmitter and receiver both on the same one of 50 frequencies. Change frequencies over twice a second, and yet wake up 10 or 20 minutes later landing on the same frequency. Makes for quick communication hookup and lower power usage.

NOTE: You can extend battery life by communicating more.
EXAMPLE: Communicating at least every 30 minutes or one hour (depends on how precise your clock is), will guarantee that when you next communicate you are still in the same dedicated frequency time slot, and do not have to find the right frequency to communicate on.

Scenario 1:

Wake up every day: “Find” for about 1 minute, then communicate for 10 msecs-→1010 msecs of activity

Scenario 2:

Wake up every hour: communicate for 5 msecs to stay in sync, communicate for 10 msecs once per day -> 130 msecs of activity

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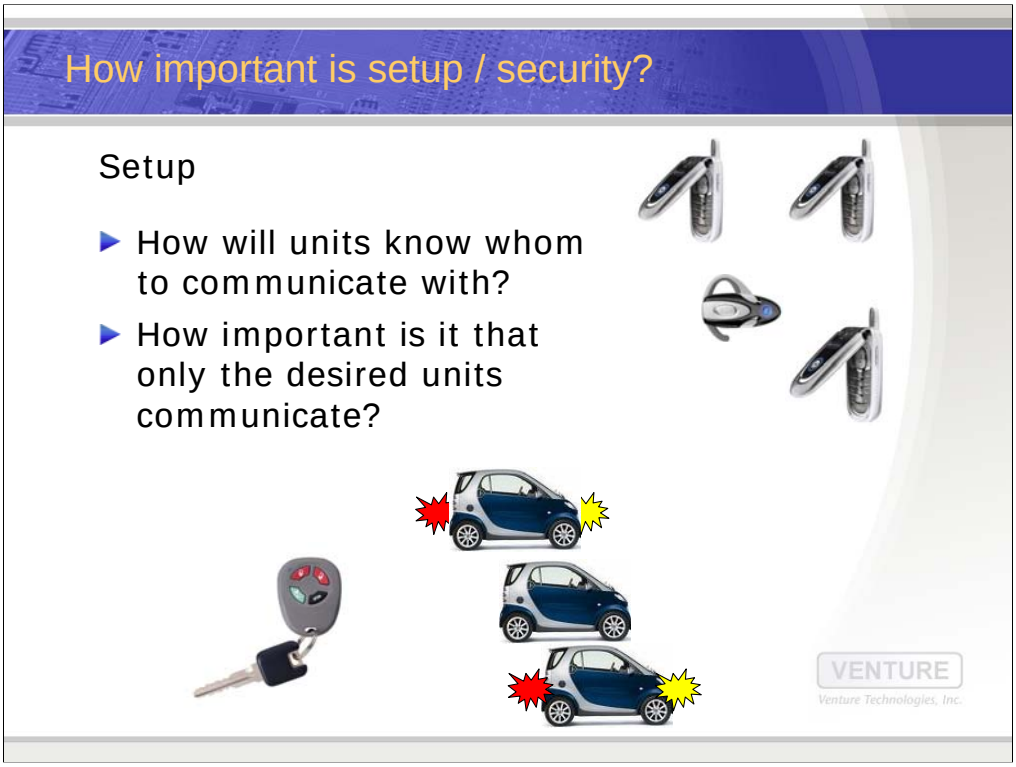

4.Setup / security

Call is commissioning, pairing, marrying….
How will units know who to communicate with?

How important is it that only the desired units communicate?

Installation

- •Factory ID – MAC address
- •In-field address setting – DIP switches or serial data communication
- •Pairing – like Bluetooth headsets
- •Replacement / additions

Data security

- •Frequency hopping (limited security)
  Changing channels more than twice a second makes sniffing data difficult.
- •Encryption – (EX: Rijndael, TwoFish)
  Added complexity of initial design, key management, and of future expansion
  Minimal processing delay.

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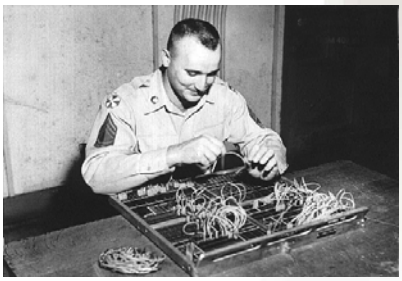

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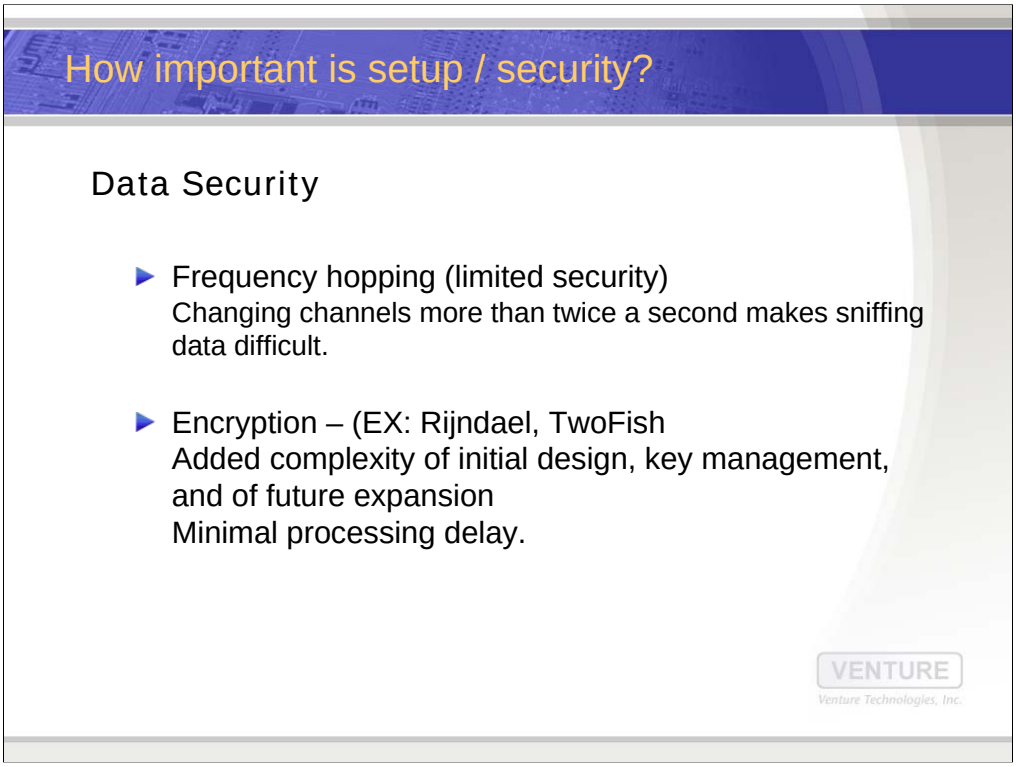

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What is your target cost & volume?

For volumes in the dozens to hundreds…

- An RF module may be the best choice.

- Consider custom in these low volumes only if:
  - Minimum size is required.
  - Maximum battery life is required.
  - Maximum range is required.

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5.These are the key issues that dictate whether to adopt a standard or whether to consider a custom solution

For volumes in the dozens or hundreds, adding a module usually makes sense

Consider custom in these low volumes only if:

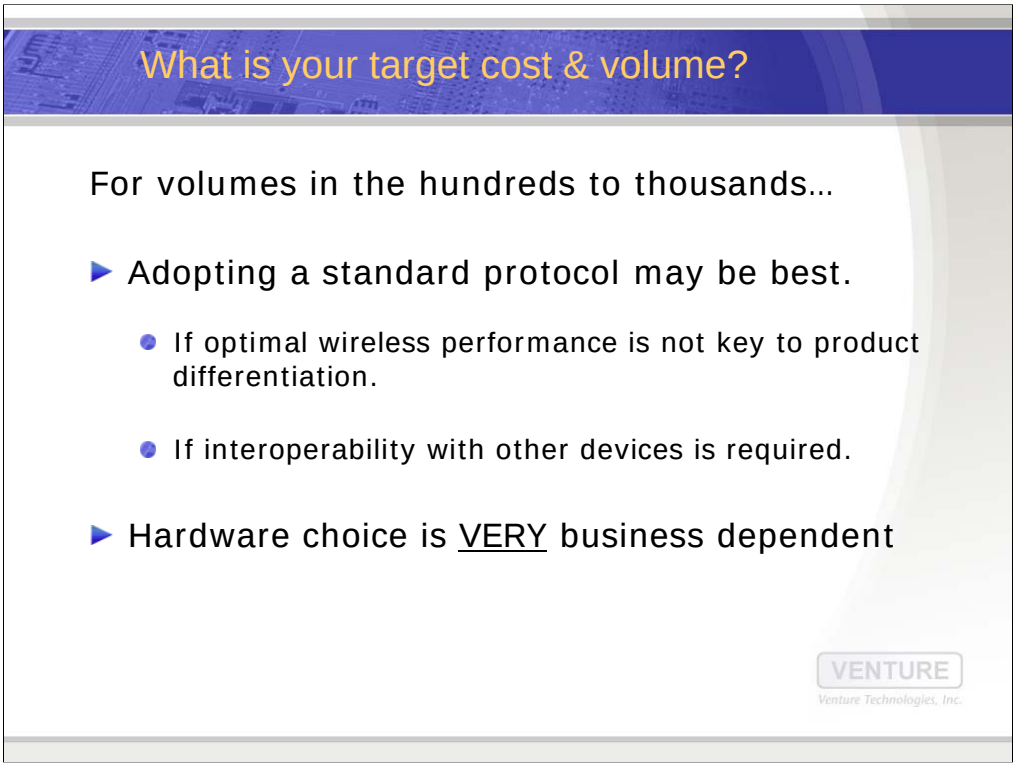
- •Smallest size is absolutely required (EX: surgical tool, military device, etc.)
  PICTURE: Surgical handtool
- •Longest battery life is required
- •Longest range is required

For larger volumes, in the multiple hundreds or several thousand, adopting a standard can be an effective strategy:

- •Optimal wireless performance is not key to the product (EX: Product does not require the longest range or the longest life batteries for market differentiation)
- •Communication with other manufacturers products is desired (WiFi, soon ZigBee)
  PICTURE: Many doors in a hotel (security system) or many overhead lights (ZigBee is making inroads here)

For volumes over several thousand, consider a custom solution for:

- •Lowest product cost
  PICTURE: Shopping cart handle
- •Maximization of all performance characteristics (battery life, range, setup, size, etc.)
- •Optimizing product performance (EX: quickest to connect, easiest to hold, etc.)



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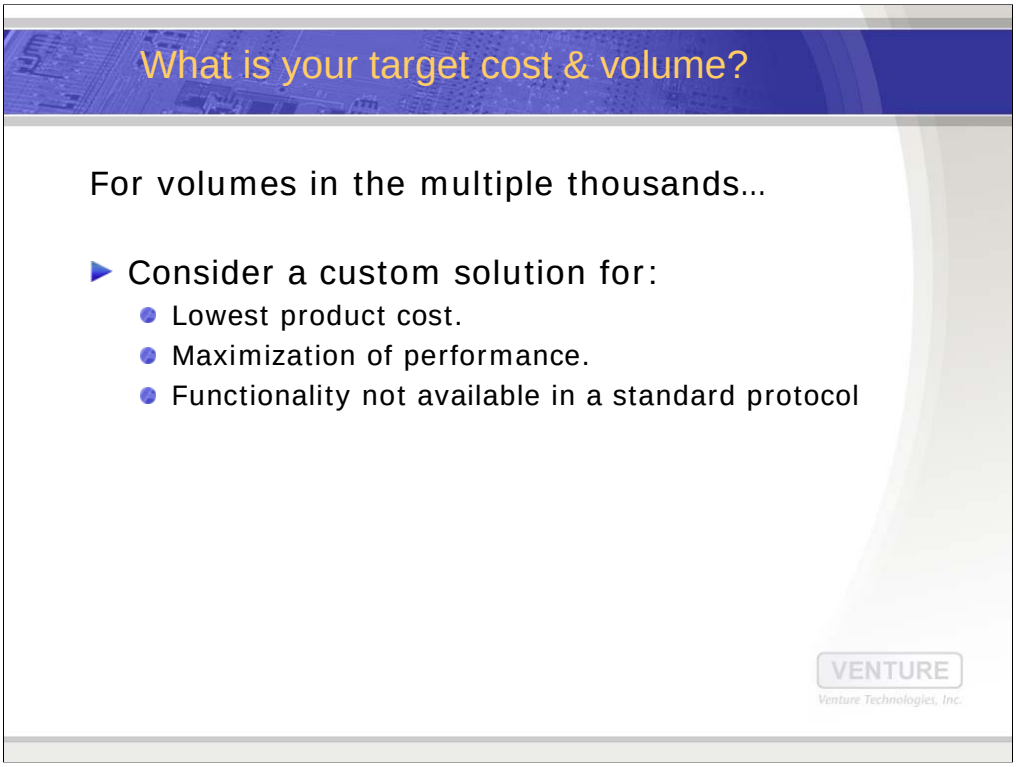

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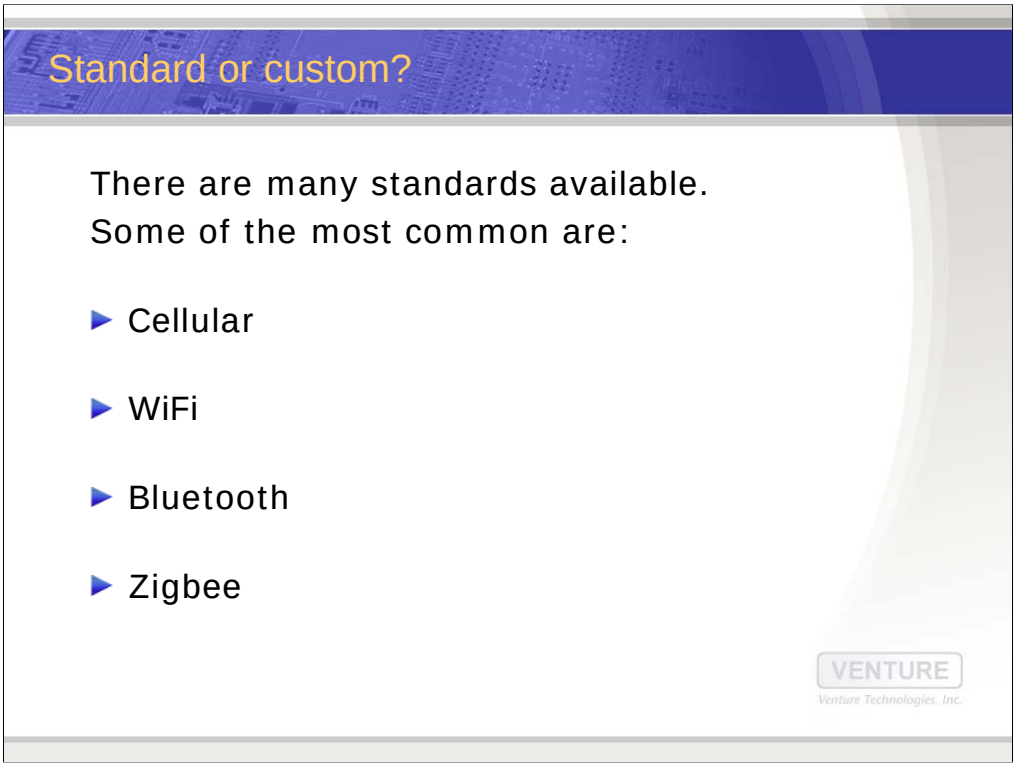

1. WiFi : Generic picture
   - •Thruput: 10's or 100's of megabits per second
   - •Range: @100 feet
   - •Content: Web-surfing or streaming video
   - •Cost: Module cost in quantity 1000's typically about $20-25
   - •Limited low-power options
   - •Usually added to a product as a separate module
   - •Product falls under control of IT department
2. BlueTooth: Generic picture
   - •Thruput: 1 megabit per second
   - •Range: @32 feet
   - •Content: Cable replacement technology, for mice and headsets
   - •Cost: Module cost in quantity 1000's typically about $10
   - •Limited low-power options
   - •Very good at forming networks ad hoc; good connectibility
3. ZigBee:

Picture: Zigbee wireless network

- •Thruput: 10's to 100's of kilobits per second
- •Range: @30-150 feet
- •Content: Input/output control or streaming audio
- •Cost: Module cost in quantity 1000's typical $15-20
- •Limited low-power options – always wants to be "on"
- •Offers promise of interconnectability but so far that is limited
- •Due to code size of @128K, often require it owns microprocessor, and thus often added as a module

Standard Protocols

Cellular

- Thruput: Thousands of bits per second
- Range: Worldwide, but you have to make a cell connection
- Content: Control info to low-quality audio
- Cost: Module cost in quantity 1000's typically about $20-25.
- Power: No low-power options.
- Usually added to a product as a separate module.
- If you cannot get a cell connection, you cannot communicate

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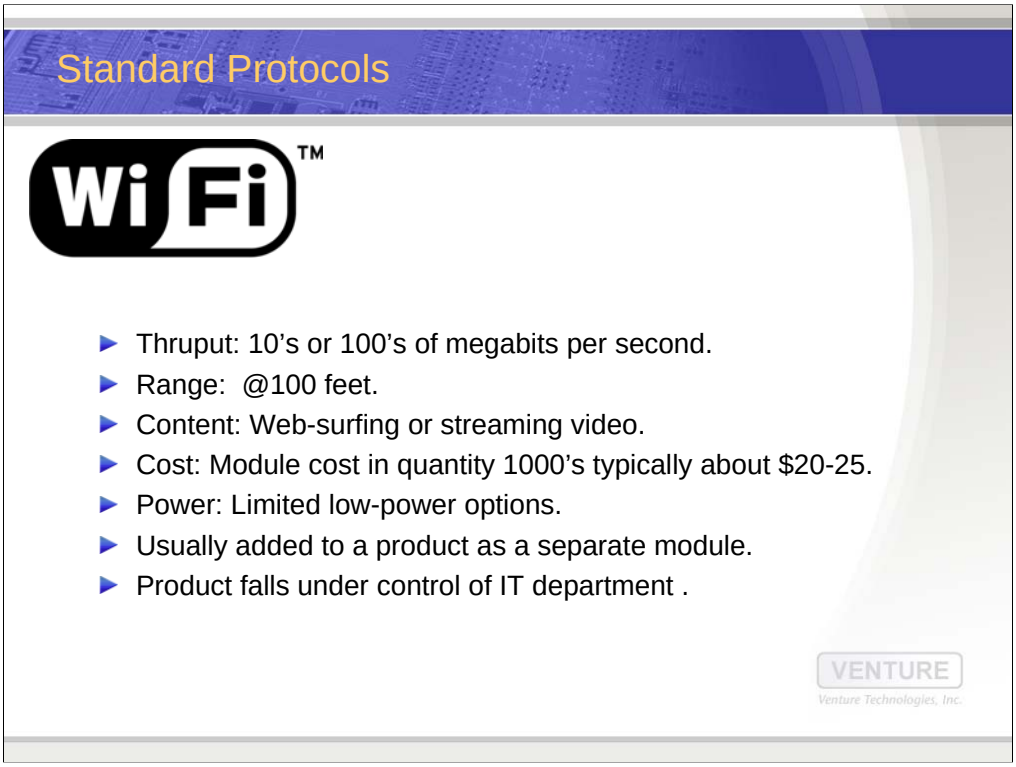

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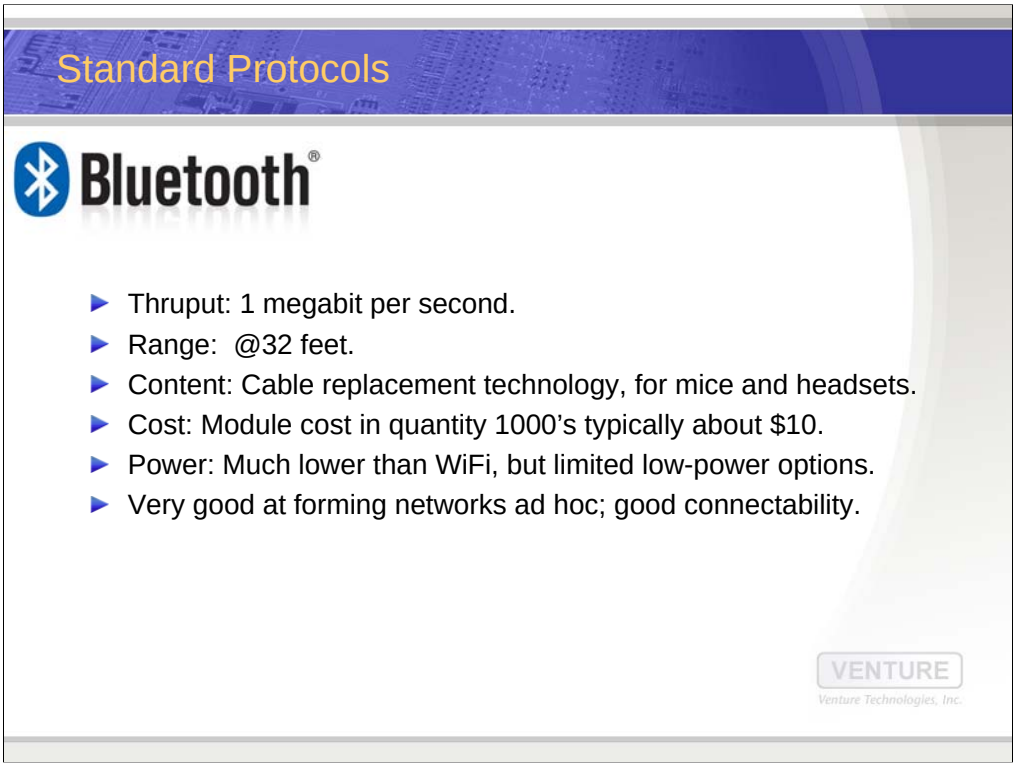

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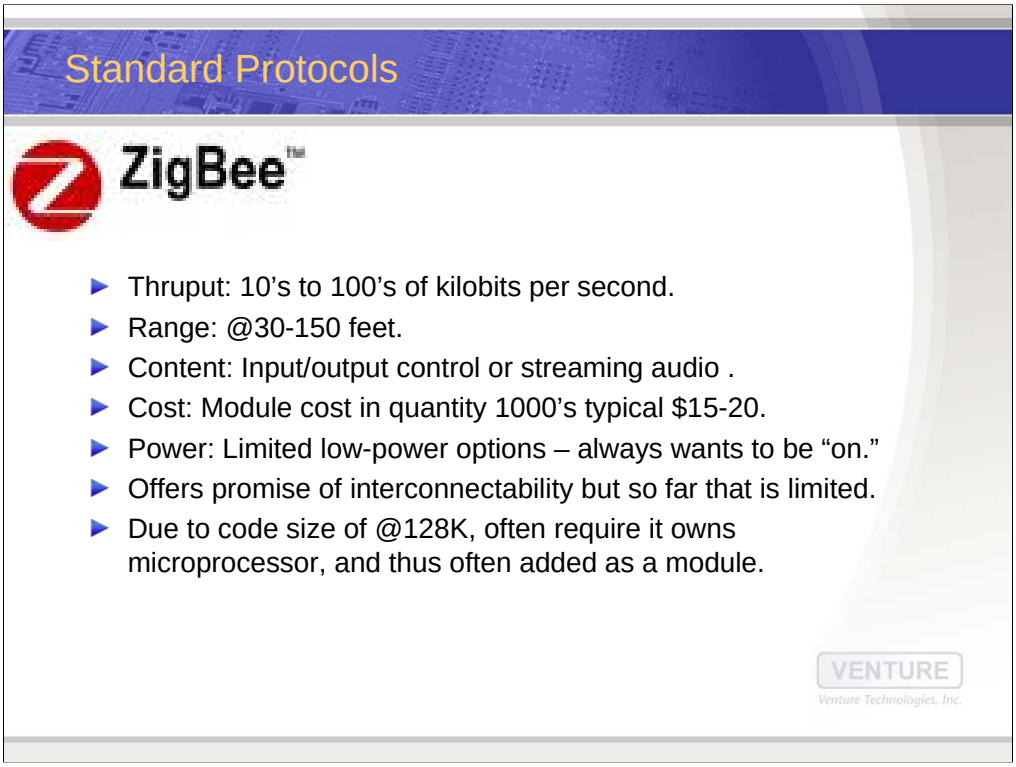

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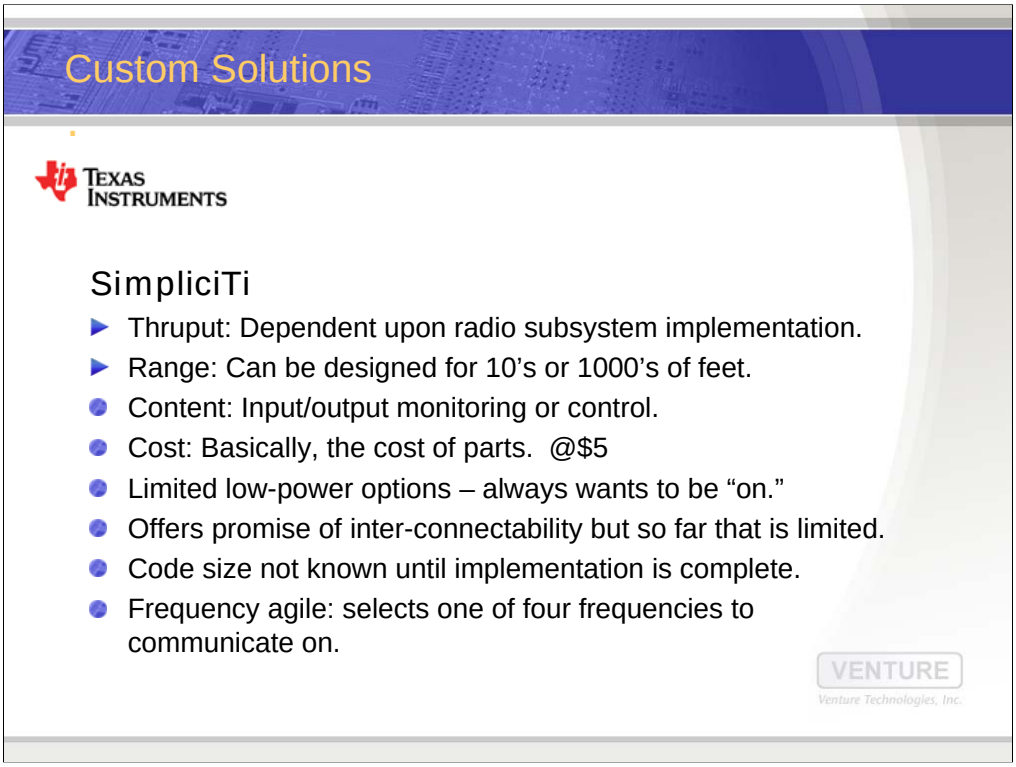

6. Standard or custom - Custom networks

1. Simpliciti (from Texas Instruments):

2. RFOS (from Venture Technologies):

Picture: Hospital handwashing station where we monitor number of hand washes performed

- Thruput: Selectable from many existing models, up to 100's of kilobits per second
- Range: Select up to several miles (hardware design supplied)
- Content: Input/output monitoring control up to streaming audio
- Cost: Increase in BOM(Bill of Materials) to existing product of $5 plus small license fee per unit
- Very good low power options – battery operated can last years
- No interconnect-ability with other company's products
- Code size minimal – From 8K to 16K, depending on options required
- Frequency hopping: Changes communications channels(uses 50) in unison every .4 seconds

Custom Solutions

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RFOS (From Venture Technologies)

- Thruput: Many different models, up to 100's of kilobits per second
- Range: Select up to several miles (hardware design supplied)
- Content: Input/output monitoring control up to streaming audio
- Cost: Basically, the cost of parts. @$5… plus small license fee
- Very good low power options – battery operated can last years
- No interconnect-ability with other company's products
- Code size minimal – From 8K to 16K, depending on options required
- Frequency hopping – Changes channels in unison every .4 seconds
  This greatly increases power levels allowed by FCC
- Comes in 433 Mhz / 902-928Mhz / 868 Mhz / 2.4Ghz

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RFOS: A world of frequency choices

International communications regulations are a significant factor in the choice of communications frequency for a custom solution

433 MHz:

- Approved for worldwide use.
- Relatively low frequency drives thru material well.
- U.S. approved power is much lower than European approved power level.
- Trick: Minimizing communications packet size and total amount of communication allows use of higher power and therefore greater range

RFOS: A world of frequency choices

902-928Mhz / 868 Mhz:

- 902-928 MHz approved in U.S. and 868 MHz in Europe.
- Uses almost the same parts, with some software differences.
- Relatively low frequency drives thru material well. 868 MHz offers less bands and lower power than 902-928 Mhz.

2.4 GHz:

- Approved for international use.
- Relatively high frequency gets interfered with easily.
- Very cluttered band, shared with WiFI and microwave ovens.
- Fits well with mesh architecture having many units close together

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