A building block approach to sensornet systems

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Problems

1. How to produce reusable hardware when the requirements vary so widely among applications
2. How to support all three phases of development
   a) prototyping
   b) pilot studies
   c) production

Approach	Pros	Cons
modular, bus-based		
highly integrated		
modular, assembly-optimized		
building block		

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modular, bus-based	• prototyping is mechanically simple	• complex interface for peripherals • requires multiplexing • too bulky/fragile/expensive for pilot and production use
highly integrated		
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building block	…	…

Building block approach

1. module
2. carrier
3. interface

Building block approach

1. module
   a) deep expertise
   b) specialized equipment
   c) frequent use
   d) convenience
2. carrier
3. interface

Building block approach

1. module
2. carrier
   a) prototyping
   b) pilot studies
   c) production
3. interface

Building block approach

1. module
2. carrier
3. interface
   a) eliminate system bus
   b) export a wide electrical interface
   c) support many physical interconnection options

Example: Epic

1. what to put into modules
2. specific hardware
3. carriers for multi-phase support

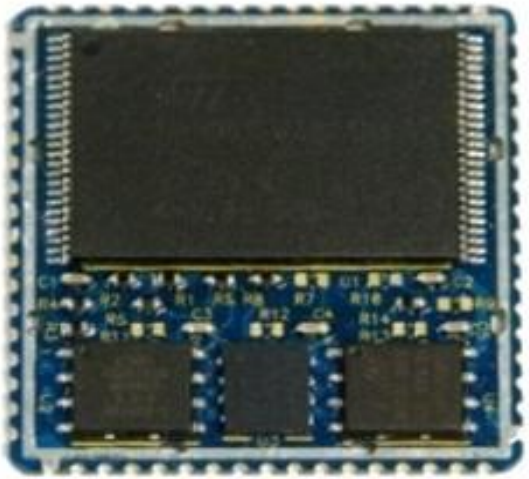
Example: Epic

1. what to put into modules
   a) core (expertise, equipment, use)
   b) USB (use, convenience)
   c) storage (equipment, convenience)
2. specific hardware
3. carriers for multi-phase support

Example: Epic

core

USB



storage

Example: Epic

1. what to put into modules
2. specific hardware
   a) core
      i. microcontroller
      ii. radio
      iii. flash
      iv. form factor, interconnections, power, exports
   b) USB
   c) storage
3. carriers for multi-phase support

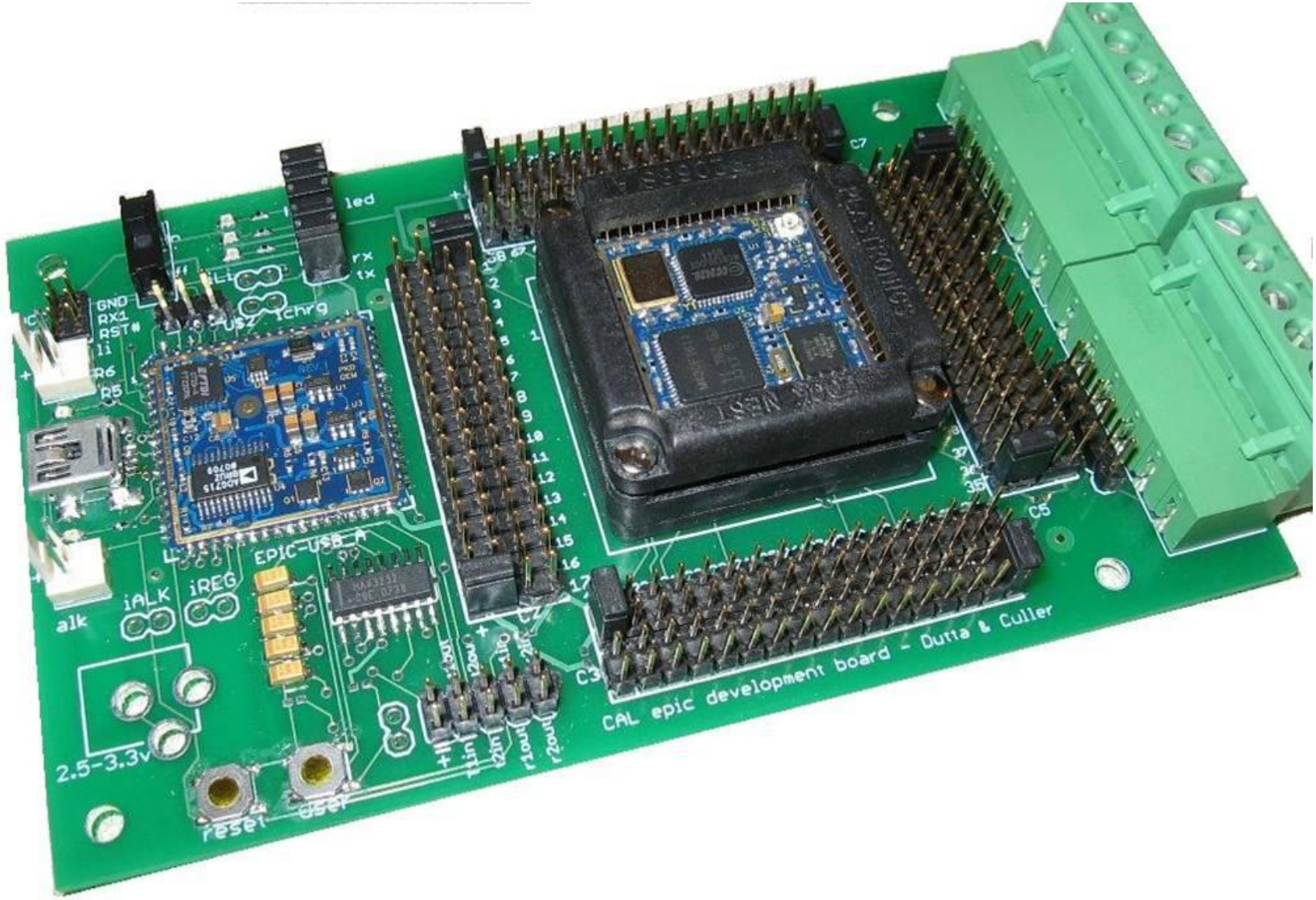
Aside: Radio energy use

$$c = c_s \cdot t_s + c_p \cdot t_p + c_t \cdot t_t + c_r \cdot t_r$$

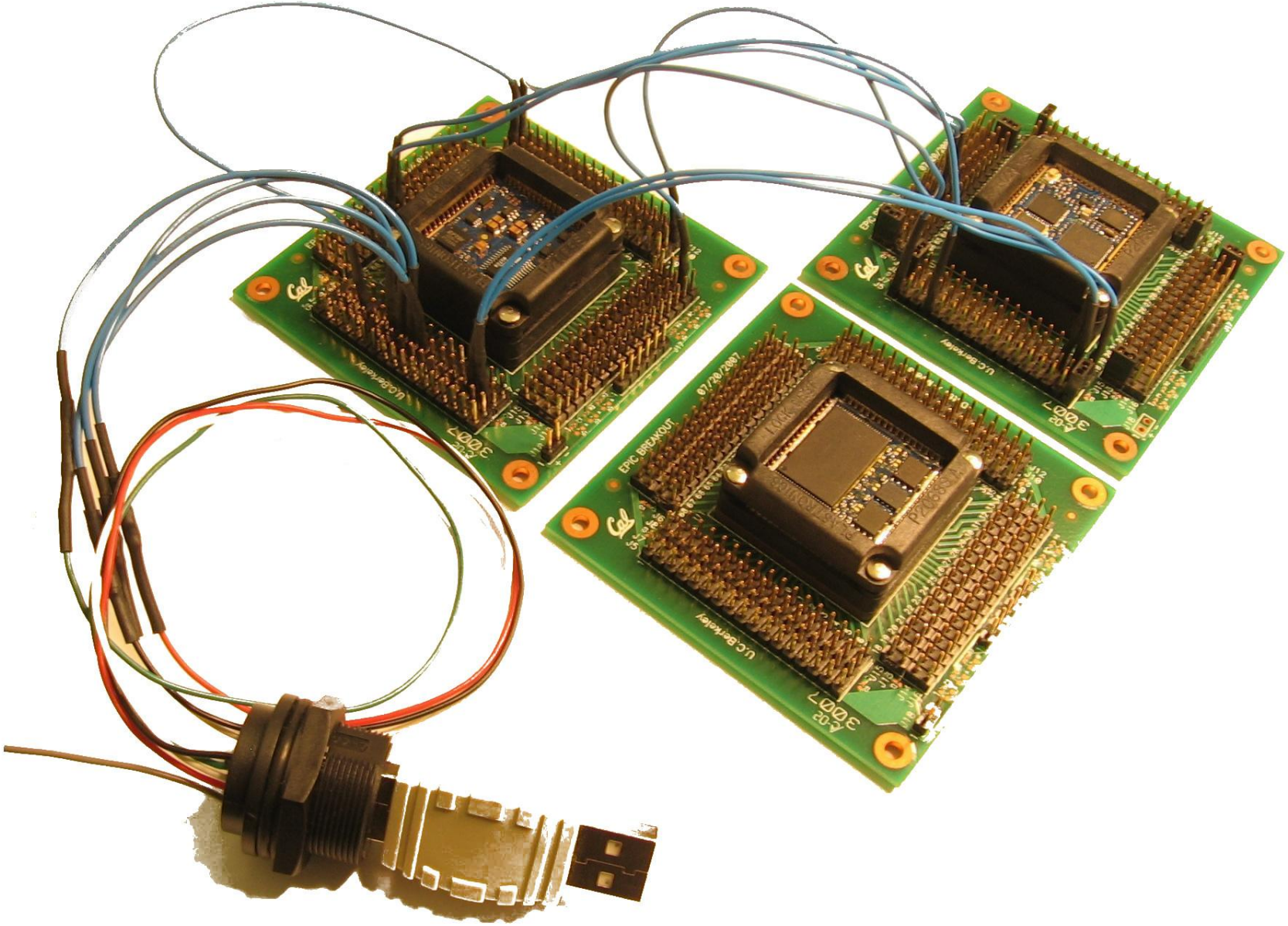
Example: Epic

1. what to put into modules
2. specific hardware
3. carriers for multi-phase support
   a) prototyping
   b) pilot studies
   c) production

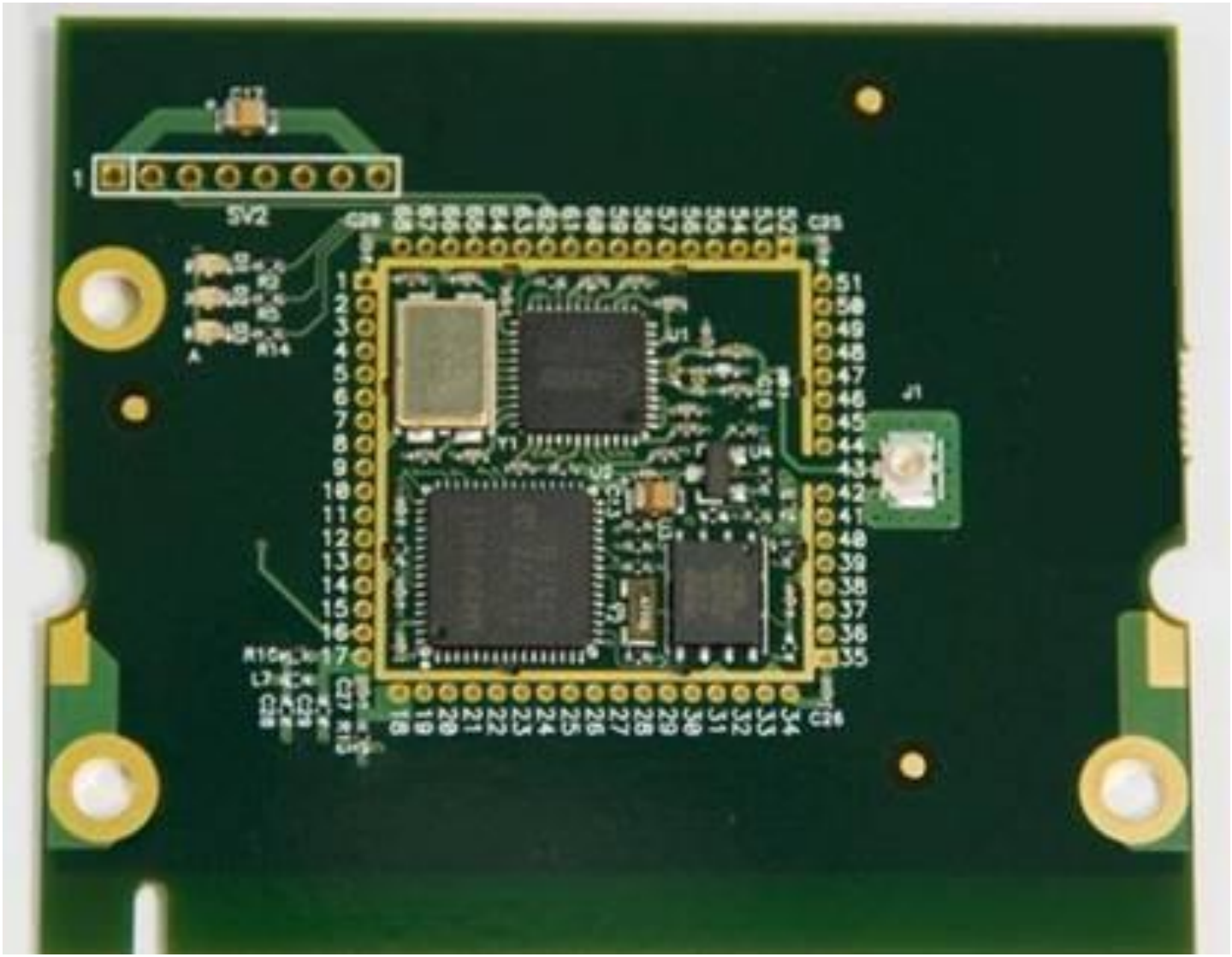
Development board



Breakout board



Hardware inlining



Epic in action

1. hydrological cycle monitoring
2. AC power monitoring
3. test beds

Epic in action

1. hydrological cycle monitoring
   - design time: 7 days $\rightarrow$ 2 days
   - unit cost: \$11.59 $\rightarrow$ \$10.83
2. AC power monitoring
3. test beds

Epic in action

1. hydrological cycle monitoring
2. AC power monitoring
   - design time: 1 week
   - unit cost: $26.40
   - “well within the constraints of most research budgets”
3. test beds

Epic in action

1. hydrological cycle monitoring
2. AC power monitoring
3. test beds
   - design time: "months" $\rightarrow$ 3 days
   - unit cost: $141.30

Issues

- non-experimental case studies
- “Our experience shows that the building block approach leads to greater reuse, more compact designs, increased simplicity, and lower overall part counts.”
- pros and cons of building block approach
- “preserve the artifacts and learnings along the way”