e-TAGs: e-Textile Attached Gadgets

David I. Lehn, Craig W. Neely, Kevin Schoonover,
Thomas L. Martin, and Mark T. Jones
Virginia Tech
dlehn@vt.edu

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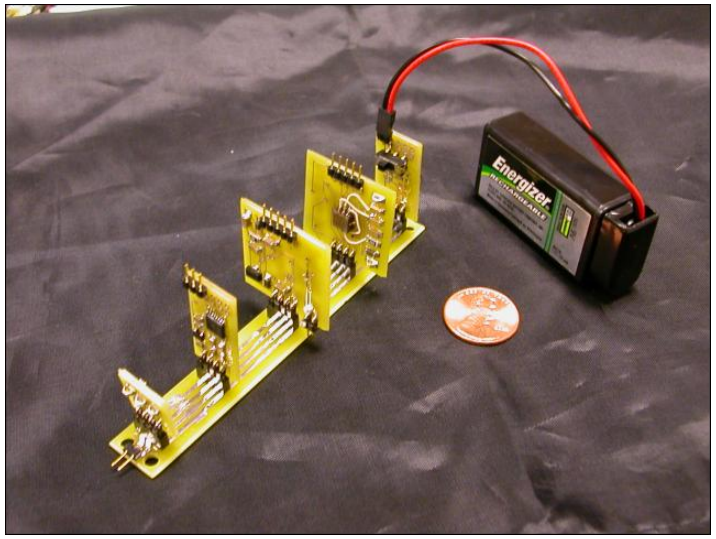
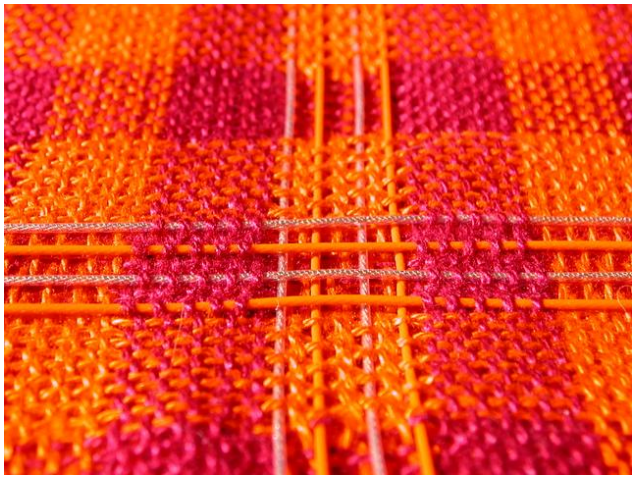
Agenda



- Electronic Textiles
  - Applications
  - Design Space
  - Simulation
  - Network Design
- e-TAGs
  - Gen 1: Large/Analog
  - Gen 2: Buttons
  - Gen 3: e-TAGs

What are e-Textiles?

- Exploit new properties of novel fibers & materials
- Communication, sensors, & actuators integrated with fabric
- . . . power also possible
- Computing closely coupled
- Use textile manufacturing techniques



Why e-Textiles?

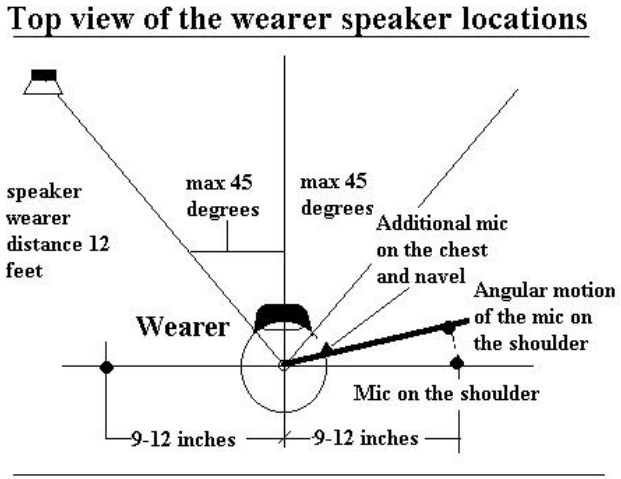
- Flexible substrates
- Platform for pervasive computing
  - Familiar
  - All around us
  - Fit into culture
  - Less invasive than alternatives
- Target domains
  - Wearable computing
  - Large sensor networks

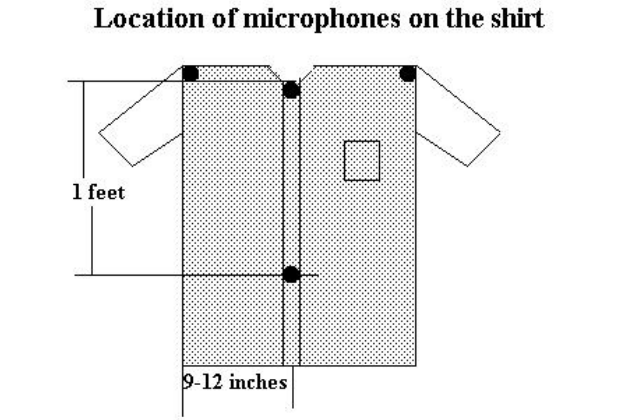
Applications

- Case studies
  - Acoustic beamformer (wearable and large scale)
  - Shape sensing garment
- Motivation
  - Both previously implemented using discrete components
  - Wearables depend on human shape, size, and movement

Application: Acoustic Beamformer

- Determine direction of sound
- Design variables
  - Number and position of microphones
  - Sampling rate
- Design metrics
  - Accuracy
  - Power consumption
- Simulation
  - Sound source
  - Beamforming (direction of source)

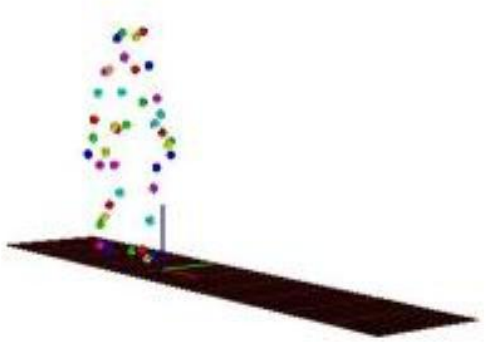




Application: Acoustic Beamformer

Application: Shape Sensing Garment

- Detect position of user's limbs and trunk
- Sensors
  - Piezoelectric: strain
  - Accelerometer: acceleration
- Simulation
  - Train on large set of people
  - Number of sensors needed
  - Sensor placement and sensitivity

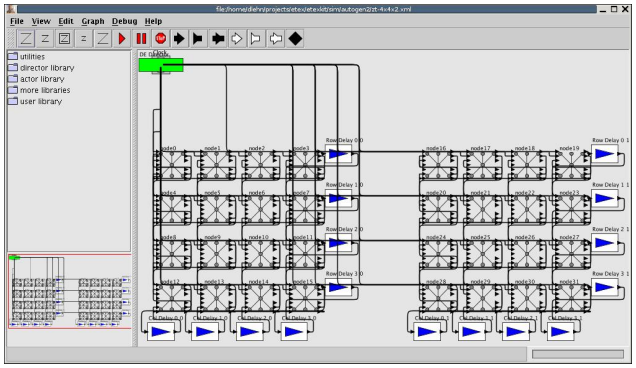


Design Space

- Huge design space
  - Textile materials, computational devices, sensors, actuators, device locations, software, networking, interconnects, power sources
- Explore with combination of simulation and prototyping
  - Prototyping alone too costly and time consuming
  - Simulation must reflect reality
- Goals
  - Generalized designs
  - . . . or try to minimize required customization
  - Common protocols and interfaces

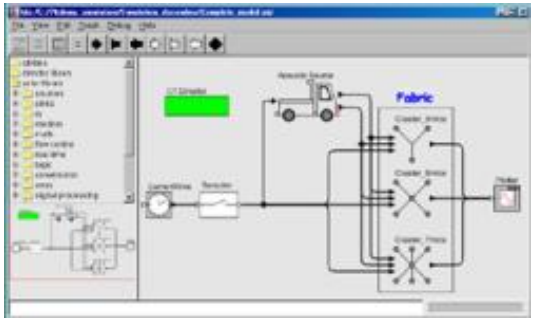
Infrastructure Simulation

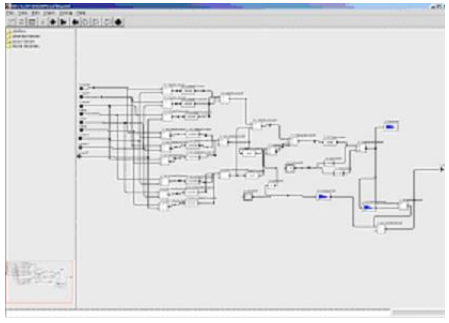
- Networking / Computation / Power
  - Similar issues to other systems: routing, bandwidth, latency, power use, fault tolerance
  - Distributed computation algorithms
  - Power important but communication cheaper than in wireless networks
- Ptolemy used for processor, network, and power simulation



Application Simulation

- Application level
  - Experiment with known data
  - Evaluate designs for a range of users
  - Extract critical design information at design time rather than after a prototype is built
- Ptolemy used for application domain physical modeling
- Use other Ptolemy models, real devices, or a hybrid



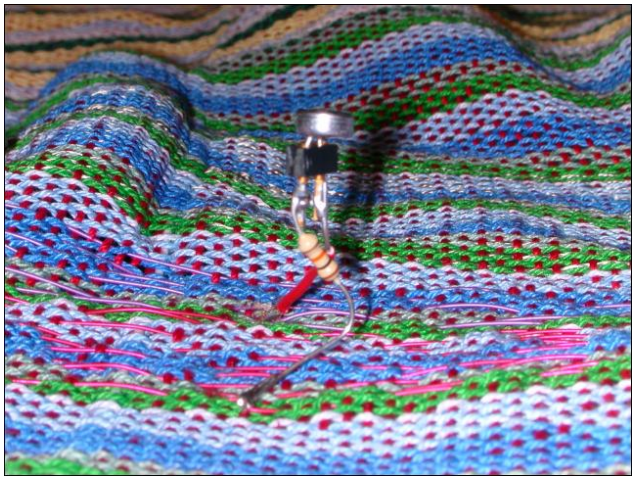


Network Design

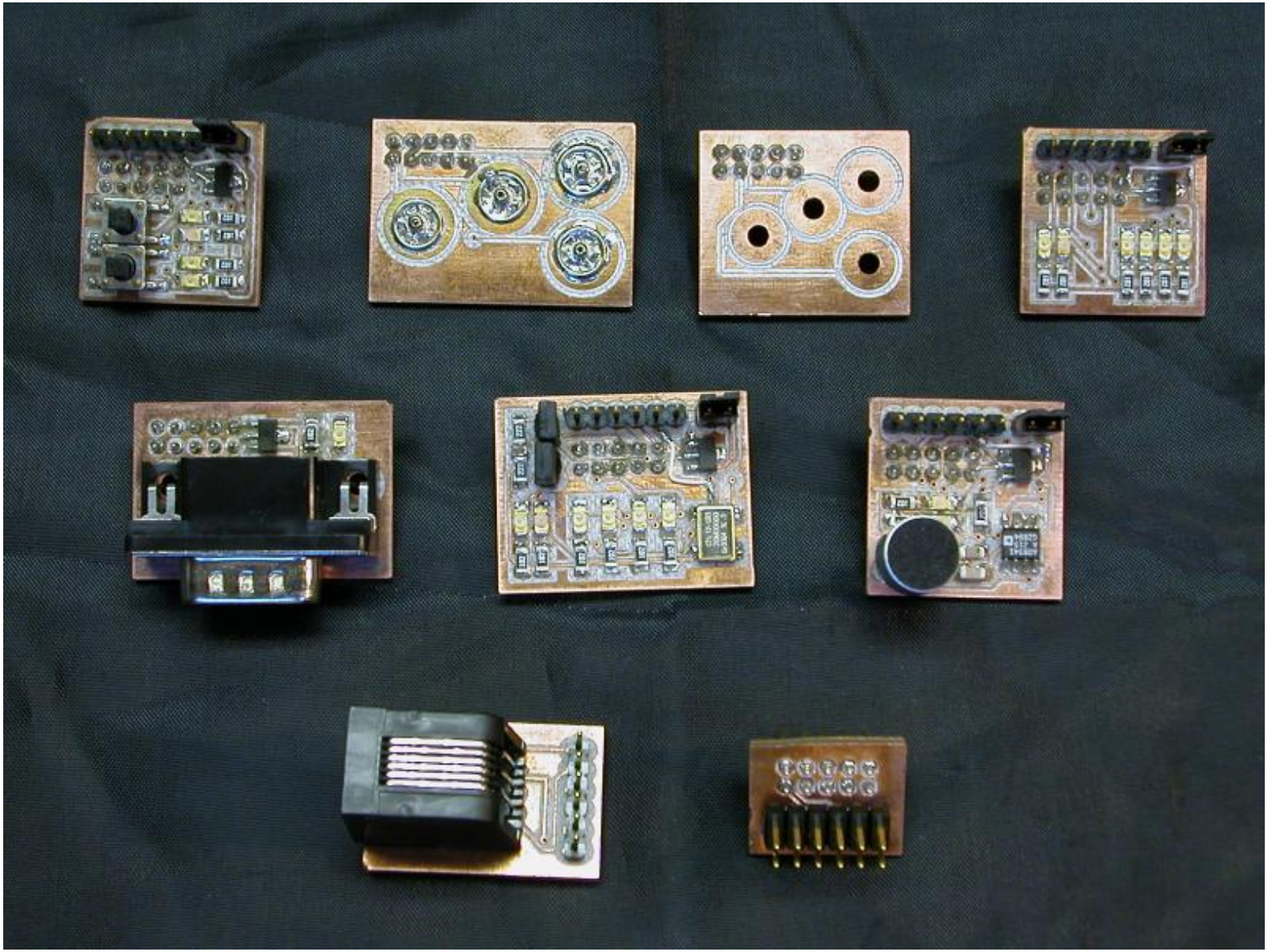
- Analog vs Digital
- Topologies
  - Point to point
  - Shared bus
  - Mixed
  - X-Y grid
- Wire count
  - Power
  - Ground
  - Clock
  - Serial / parallel data
- Digital Protocols
  - I^2C
  - CAN-bus
  - RS-232/485
  - Ethernet / USB / FireWire / etc
  - Many many more...
- Desire
  - Minimum bitrate
  - Robust to errors
  - Simple hw/sw

Generation 1: Large/Analog

- Serial point to point communication
- Analog microphone data *on fabric*
- Digital and power noise
- Monolithic hardware w/ DSP
- Application specific

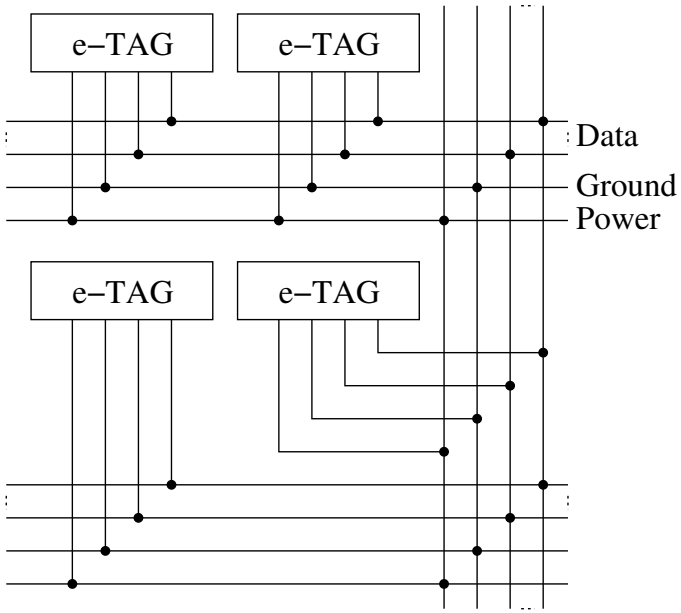


Generation 2: Buttons



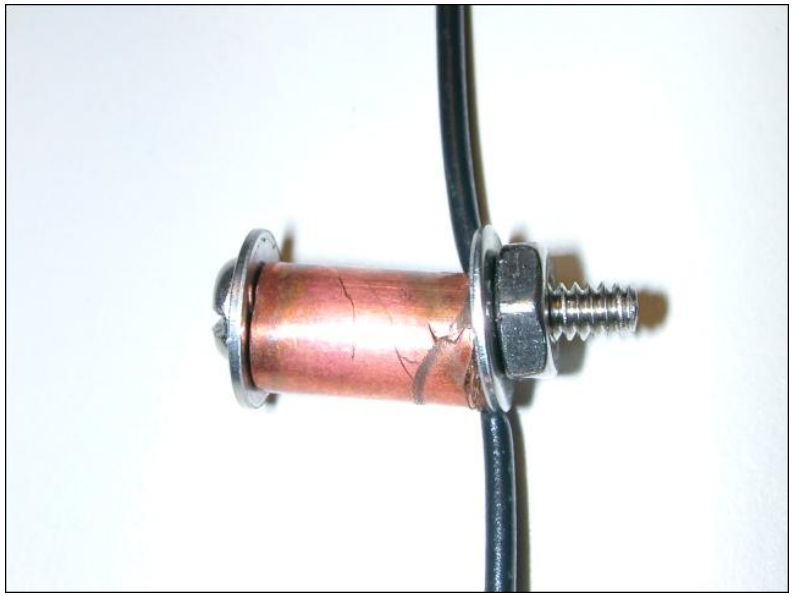
Generation 2: Connections (1/2)

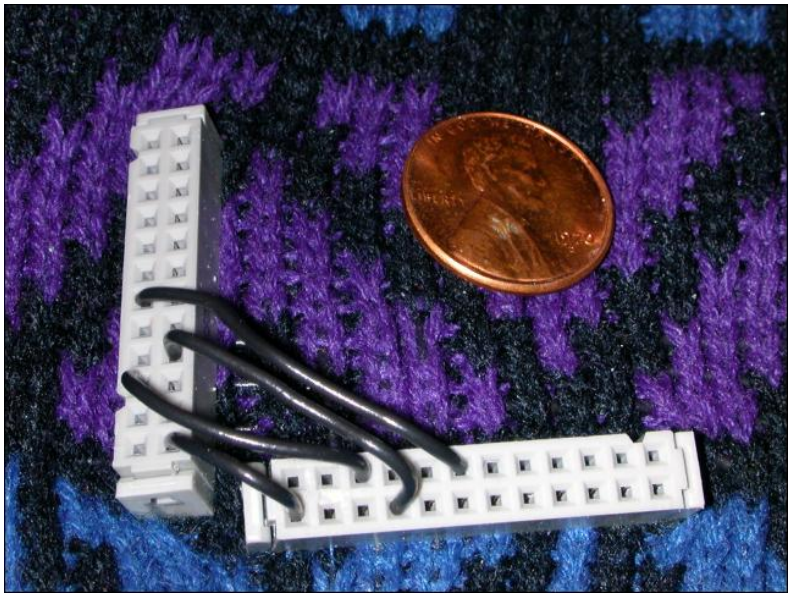
- Connection constraints
  - Wire count
    (4 for I^2C)
  - Connection size
  - Durability
  - Fault tolerant
  - Ability to reuse
  - Easy to make



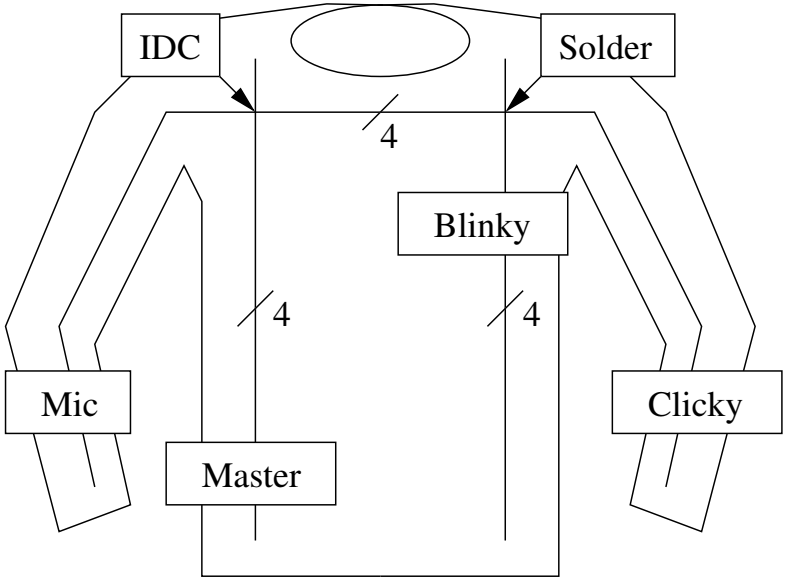
Single shared I^2C bus

Generation 2: Connections (2/2)

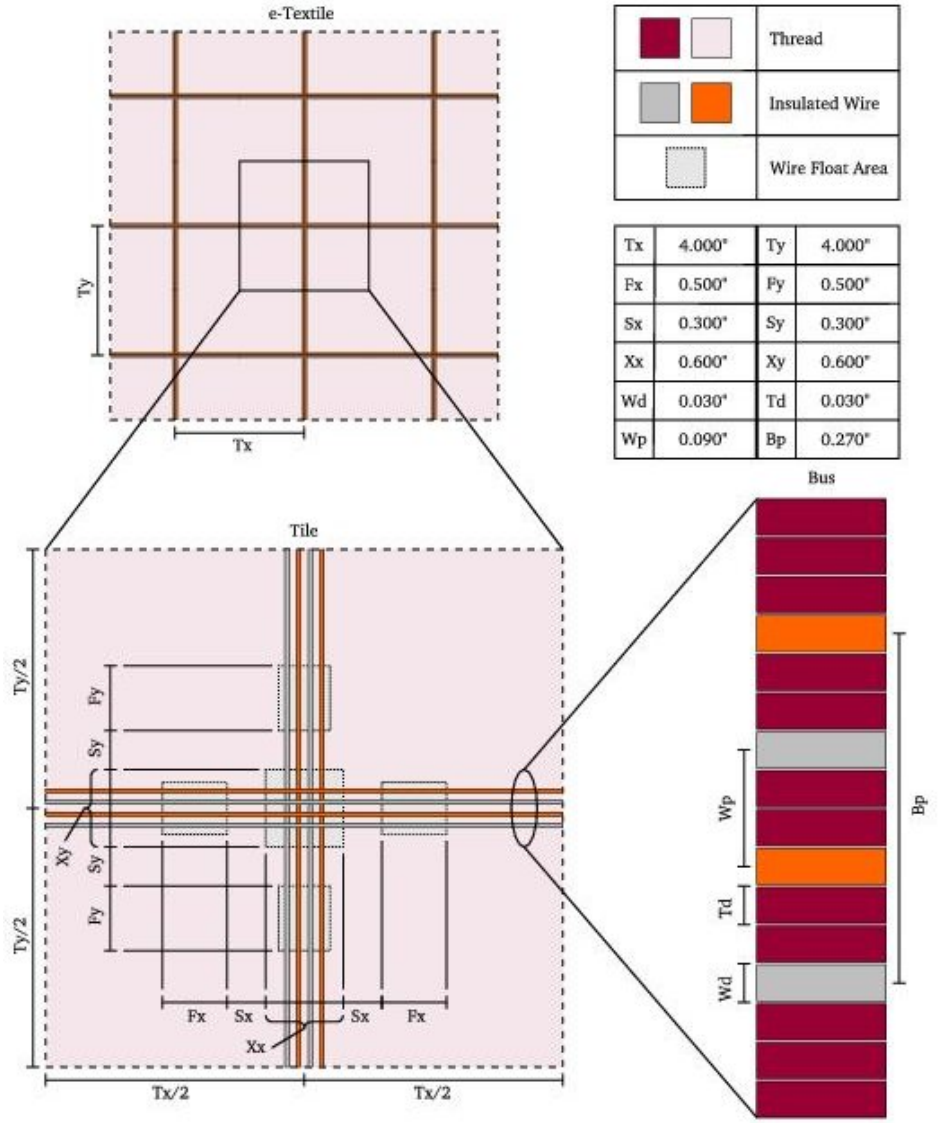


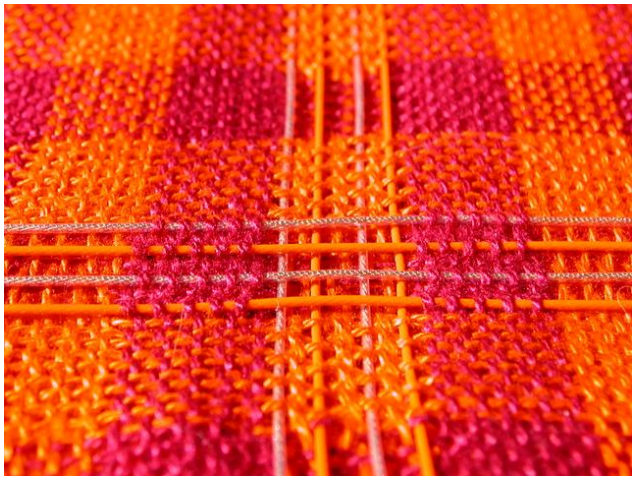


Generation 2: Sweater



Generation 3: e-Textile Fabric

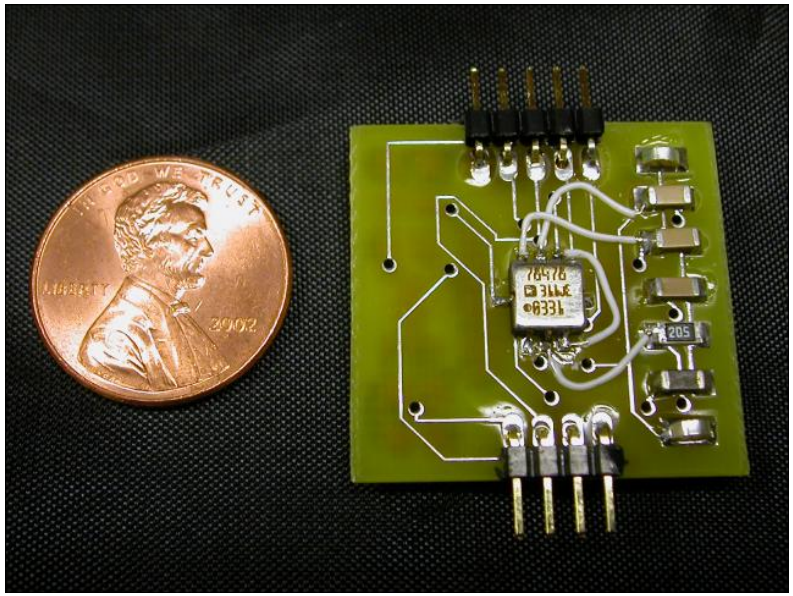


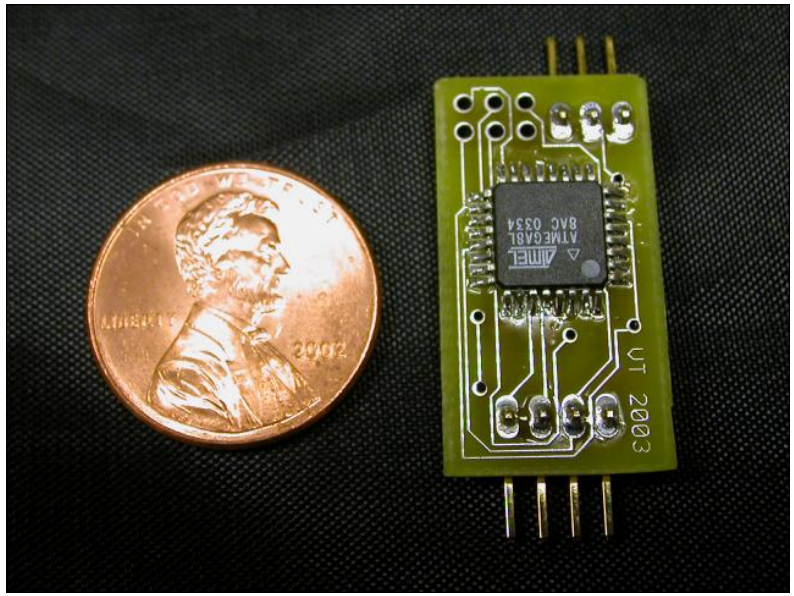


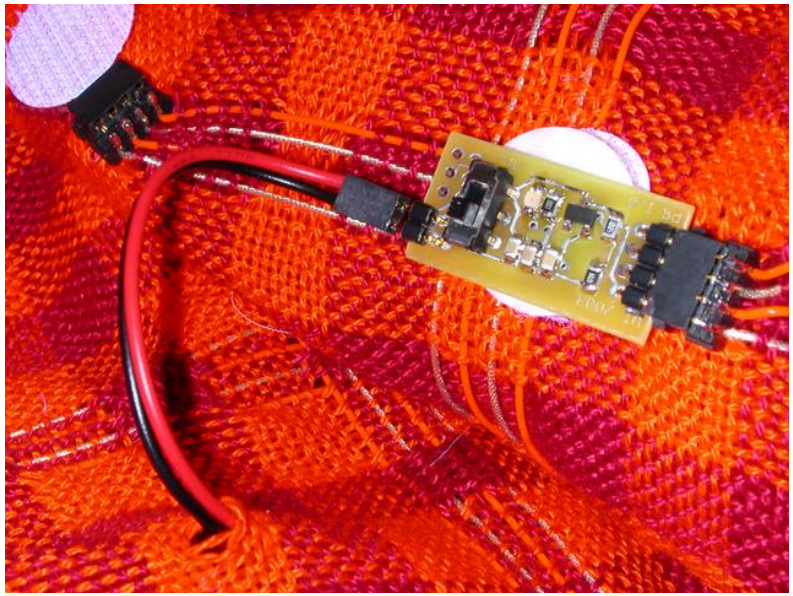
- Regular design
- 4-wire buses
- X/Y grid
- Wire "floats"

Generation 3: Vest & Pants

Generation 3: e-TAGs







Conclusions & Future Work

- Conclusions
  - Large design space, need simulation
  - Simplify wiring and connections
  - Reusable hardware components
  - Design software & hardware for hybrid simulation
- Future Work
  - Networking and programming
  - Fault tolerance
  - Power distribution

Acknowledgements

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Q & A

David I. Lehn <dlehn@vt.edu>
http://www.ccm.ece.vt.edu/etextiles/