Green Systems: From Platform to OS

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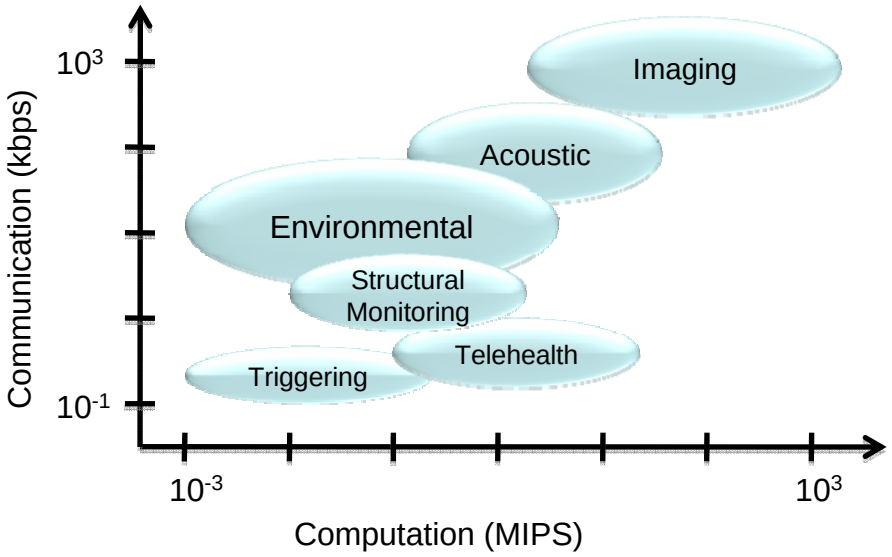
Dustin McIntire

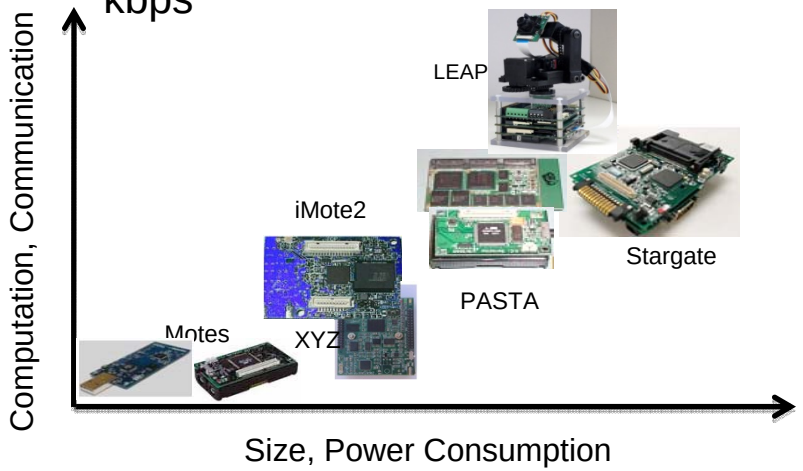
Many shades of Green…

Sensing Application Requirements



- No single processor or radio spans this range efficiently
  - A mix of complementary components is better suited
  - Components arranged in a staged or tiered fashion enable selective activation

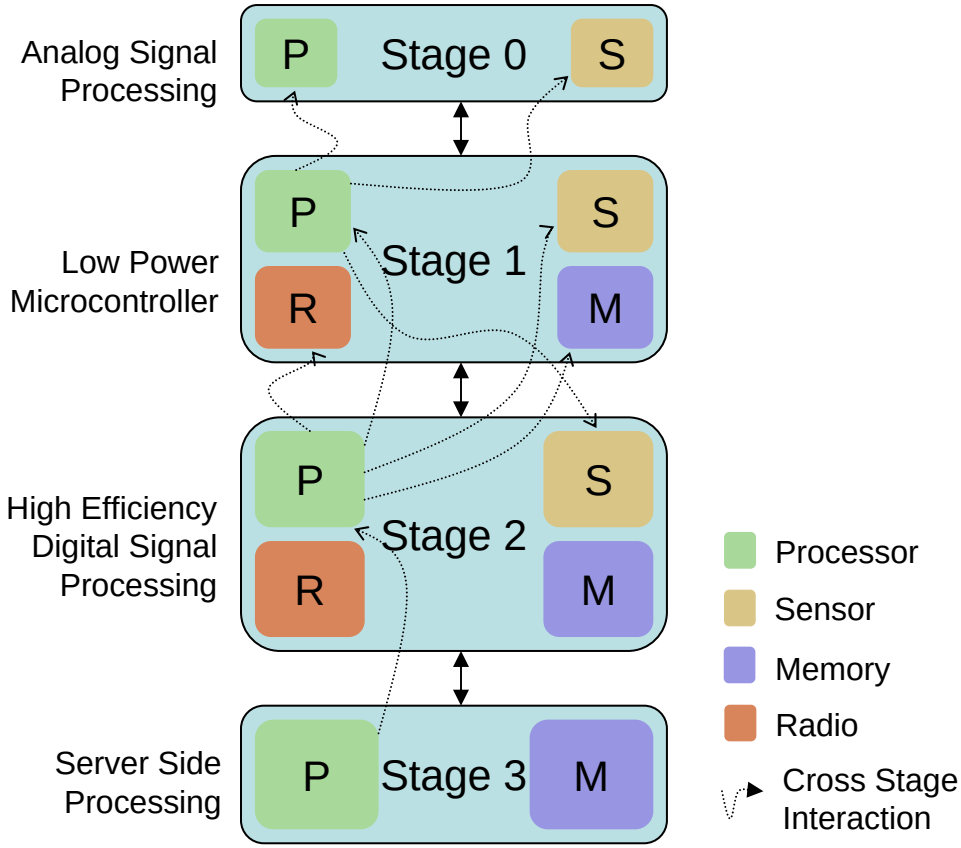
- Resource needs of wireless sensor nodes have high dynamic range
  - Sensing tasks require from 10^{-3} to 10^3 MIPS even on the same node
  - Communication requirements across nodes range from 10^{-1} to 10^3 kbps



Platform Capabilities and Cost

ASPIRE Staged System

- Stages of complementary components provide high dynamic range of capabilities

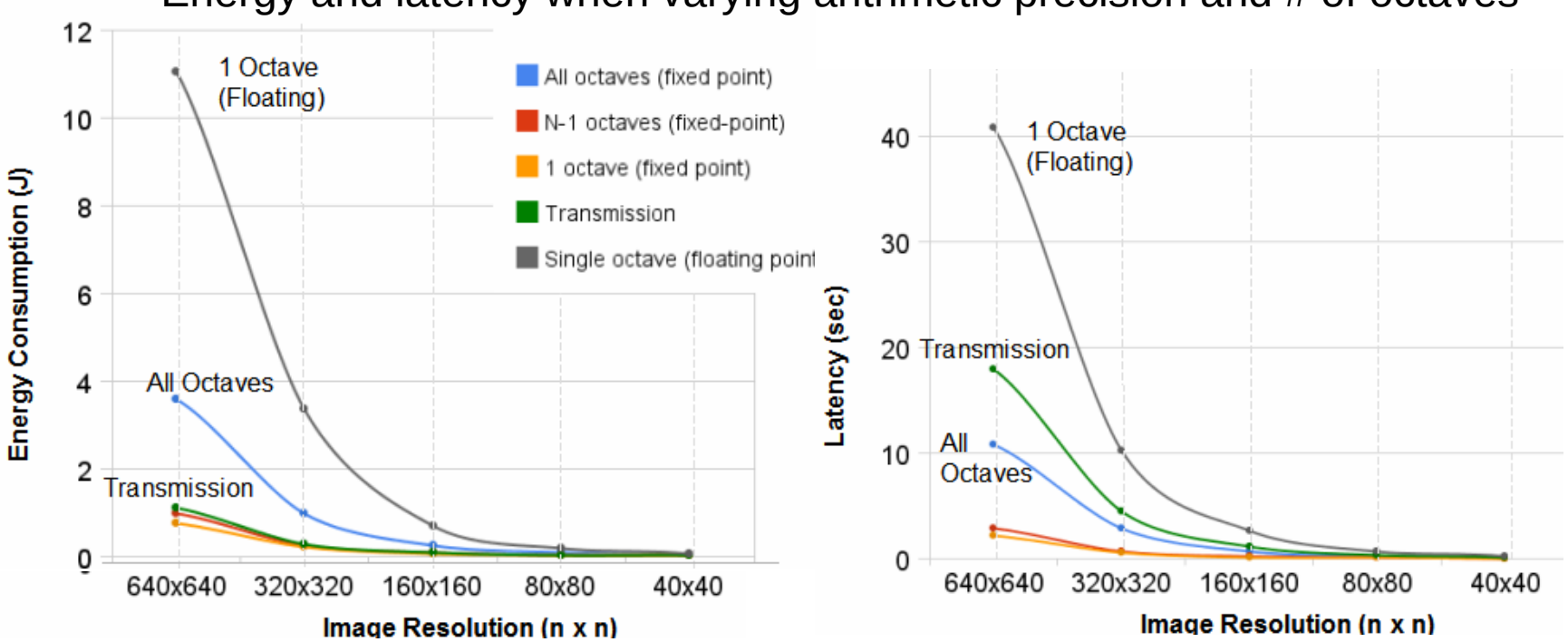


- Staged design raises interesting research issues
  - Optimal stage activation policies based on ‘event context’
  - Interconnect architectures for ‘context transfer’ across stages
  - Lowering transition times between stages exchanging ‘context control’
  - Energy aware resource management at OS level
  - Lowering quiescent power consumption

Exploring Stage Activation Tradeoffs

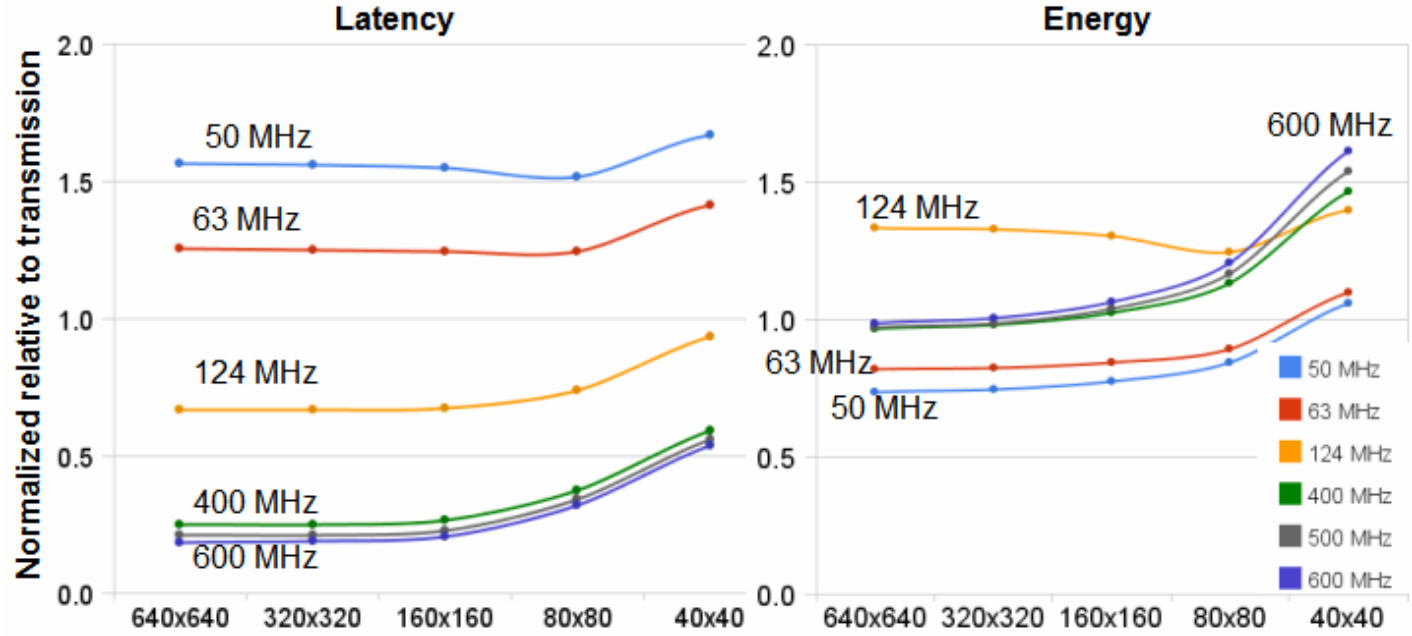
- In an image sensing application, should object recognition be performed on Stage 2 or Stage 3
  - Some results applying SIFT on a Blackfin DSP for Stage 2 and transmitting raw image over radio for Stage 3

Energy and latency when varying arithmetic precision and # of octaves



Exploring Stage Activation Tradeoffs

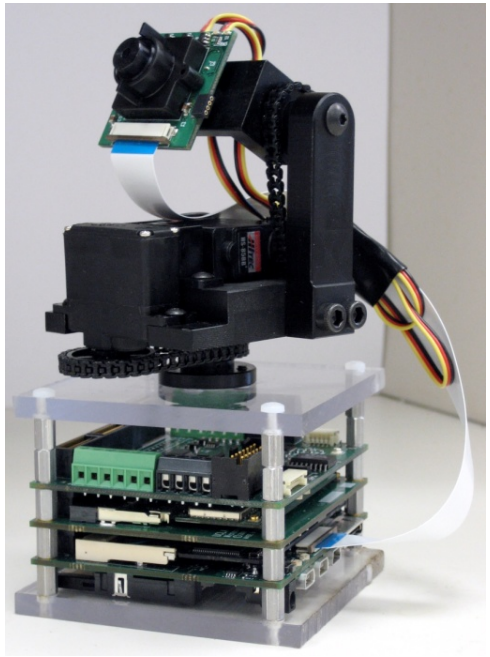
Energy and latency when varying CPU frequency
(Normalized with respect to transmission)

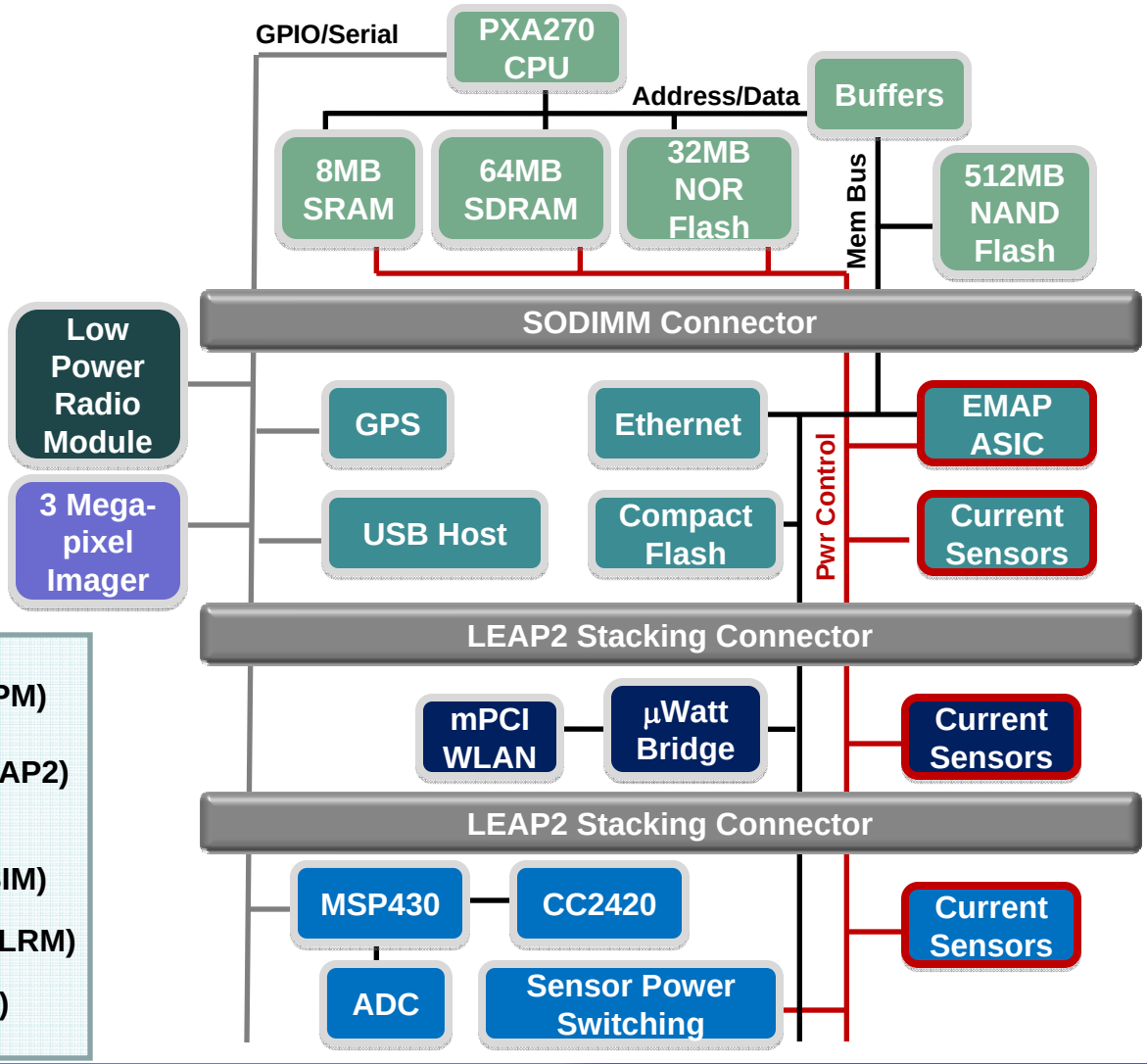


Teresa Ko, Zainul M. Charbiwala, Shaun Ahmadian, Mohammad Rahimi, Mani B. Srivastava, Stefano Soatto, Deborah Estrin, "Exploring Tradeoffs in Accuracy, Energy and Latency of SIFT in Wireless Camera Networks," *Proceedings of the First ACM/IEEE International Conference on Distributed Smart Cameras (ICDSC-07).*

Energy Aware Platforms - LEAP

CENTER FOR EMBEDDED NETWORKED SENSING





- Host Processor Module (HPM)
- Energy Management and Accounting Processor (EMAP2)
- Mini PCI Module (MPM)
- Sensor Interface Module (SIM)
- Low Power Radio Module (LRM)
- CMOS Imager Module (CIM)

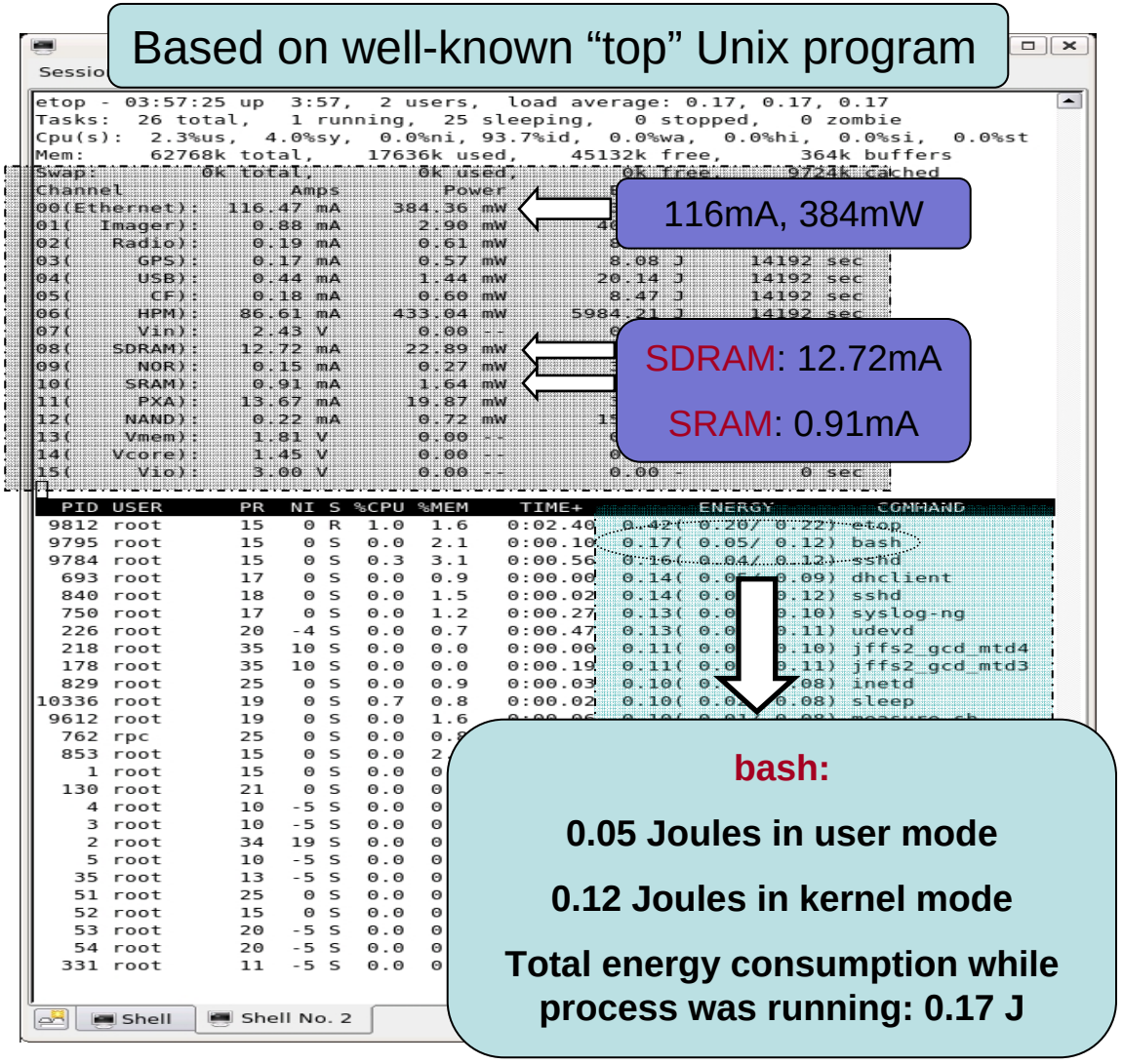
etop – Per Process Energy Accounting

CENTER FOR EMBEDDED NETWORKED SENSING

Real-time display of per-subsystem current/power/energy consumption

Real-time display of **per-process** energy consumption

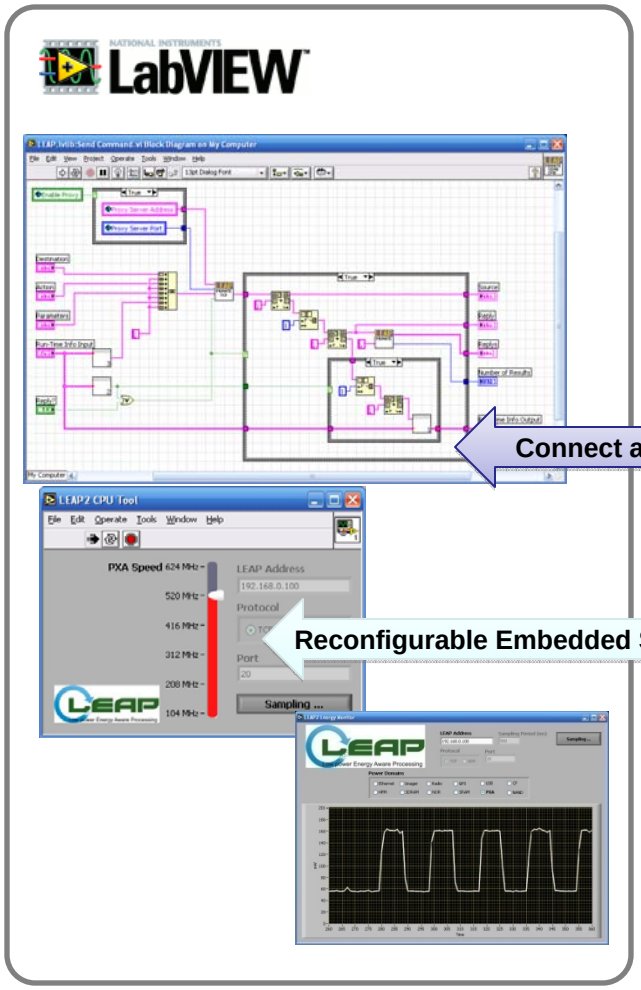
Scheduler modifications: measure consumption during **system/user time**



•Thanos Stathopoulos

LabVIEW for Energy Aware Systems

CENTER FOR EMBEDDED NETWORKED SENSING



•Timothy Chow

LEAP
Low power Energy Aware Processing

NATIONAL INSTRUMENTS

LabVIEW Domain

LabVIEW Virtual Instrument Support Layer

LabVIEW Embedded Application

LabVIEW Embedded Run-Time Engine for LEAP

Sensor Network SA Database

•Surrounding Motes Database
•Sensors Availabilities
•Cluster Topology

Web Services

•Apache Web Server
•SOAP/XML-Based Applications

Application Domain

C/C++ | Python | Scripts | Java

Detection Algorithms

•Hardware Triggers
•MATLAB Scripts
•Embedded Solutions

Mesh Network Routing Protocols

•CentRoute
•OLSR

Energy-Aware Embedded Linux

Comm Links | LEAP2 Hardware | Energy Accounting

UCLA Telehealth: Driver for greener systems

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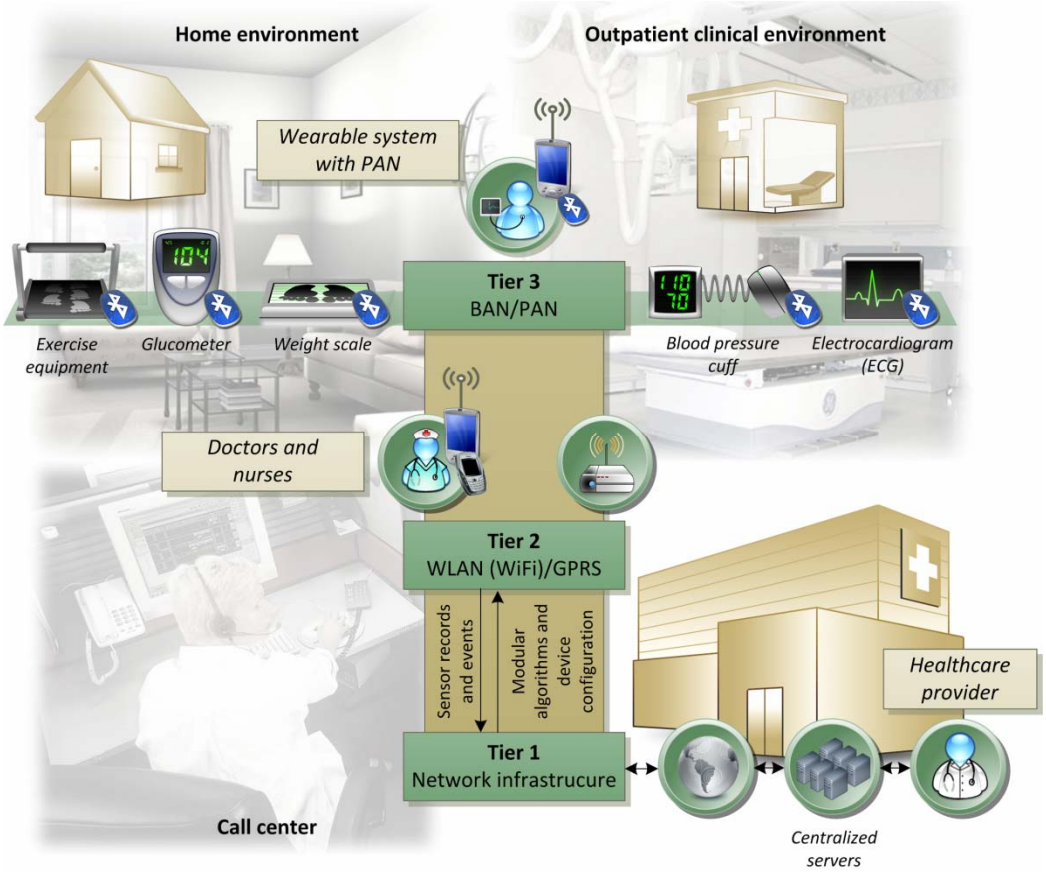

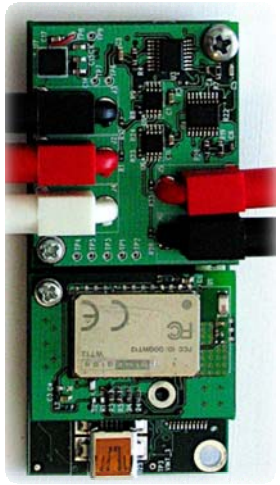

µLEAP
energy-aware
Telehealth
Platform
• Lawrence Au

Smart Cane
Training and guidance
in fall *prevention*

Collaboration Sarrafzadeh (CS), Sayed (EE), Fang (Geriatrics)

UCLA USC UCR CALTECH UCM