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Tomorrow is Yesterday (or nearly so)

Historical lessons that foretell the future of mobile and (connected) embedded systems

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Overview

- Retrospective
- Fundamental challenges
- Predictions, Guesses
- One Possibility
- [digression] A Personal Embedded Systems Journey
- Conclusions

Retrospective

- Each generation of computing resembles the past
  - Mainframe
  - Minicomputer
  - PC
  - Mobile
  - Connected Embedded Systems?
- Value shifts in predictable ways
  - Hardware to Software
  - Standard Platform is the turning point

Example: PC Evolution

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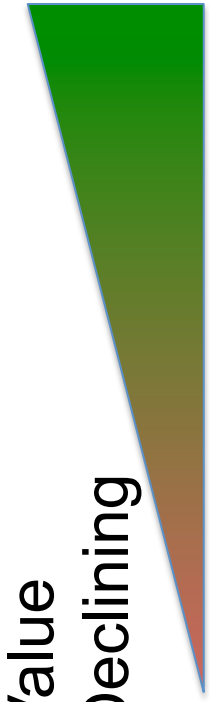

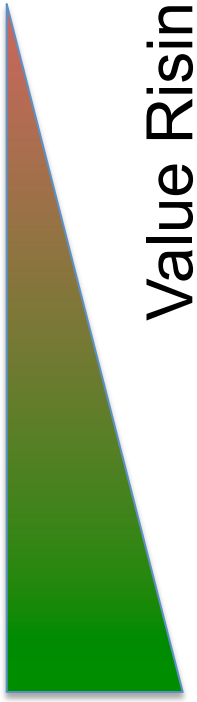

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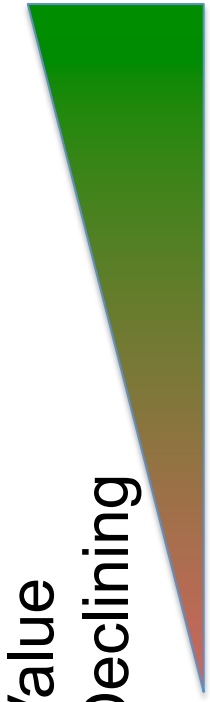

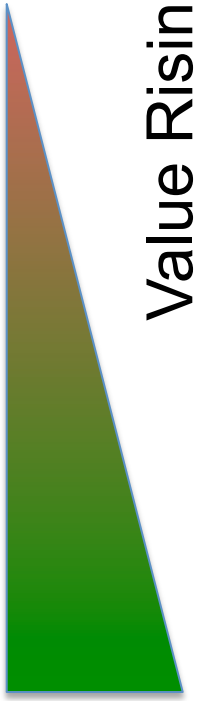

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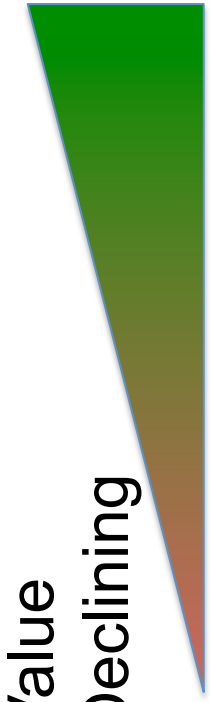

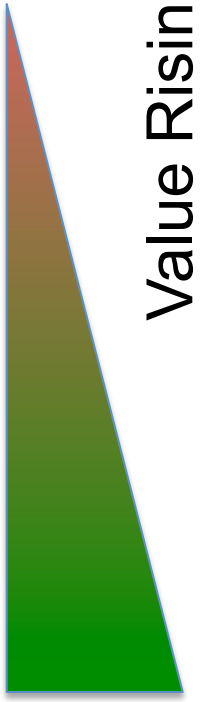

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	Compatibles (Android)	Shift to software that *takes advantage of the inherent nature of mobile*
	Commoditization (exception: ???)	Focus shifts to maintaining networked fleets of mobile devices

Mobile: Fundamental Challenges

- Power three-watt limit
- Performance computing *and* networking
- Pixels both out and in
- Pointing evolve beyond PC
- Privacy very broad issues
- Policy Management BYOD
- Programmability *embedded thinking failed!*

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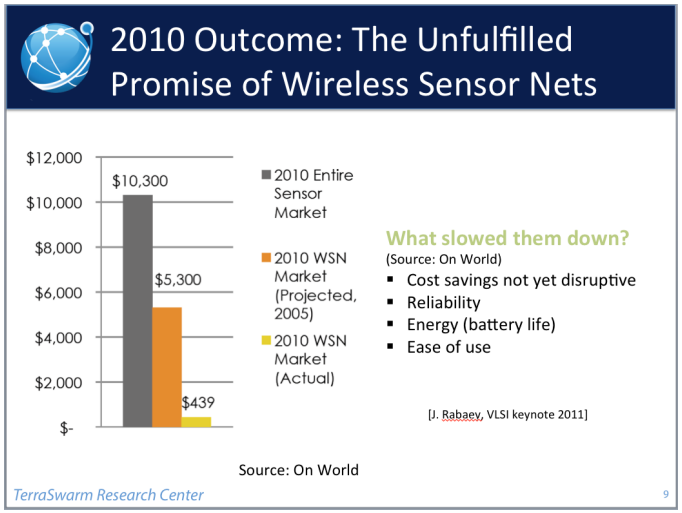
No software building blocks	Closed, proprietary software	Readily-available, high quality software including cloud services

What About the Next Generation?

- Connected Embedded Computing
  - Enabling technologies
    - Energy efficient local processing
    - Siting and location-determining techniques
  - Network-composition technologies
    - Ad-hoc, untrusted, federated elements
    - Piggybacking and "drive-by" sensing
  - Cloud service technologies
    - Sensor data aggregation tools – abstraction
    - Sensor data marketplaces, SSaaS
    - Cloud-side energy management of sensor fleets



Source: Ed Lee

No Standard Platform in sight!

Predictions, Guesses, and Research Topics

- Mobile inherits full complexity of distributed computing
  - Next wave of apps and cloud-hosted app frameworks
  - Really hard problems exacerbated by scale
- Computer vision processors will be the “GPUs” of mobile
  - Camera as primary input device
- Bypass: an Un-network mobile ecosystem will emerge
  - Throwing off now-incorrect assumptions
  - Will be applied in emerging economies and will transform them
  - In the news: Survivable Social Network
- Next-Gen leaders will focus on research-at-scale
  - Build testbeds with 40-60dB of dynamic range
  - Heterogeneity, federation, platformization will be hot topics
  - Opportunity to learn what questions to ask

And now for something completely different…

but still embedded…

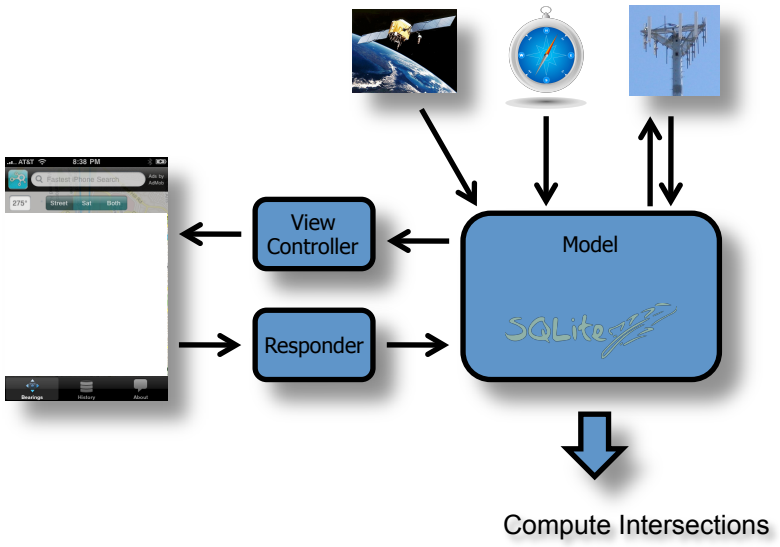
Radio Direction-Finder as Sensor

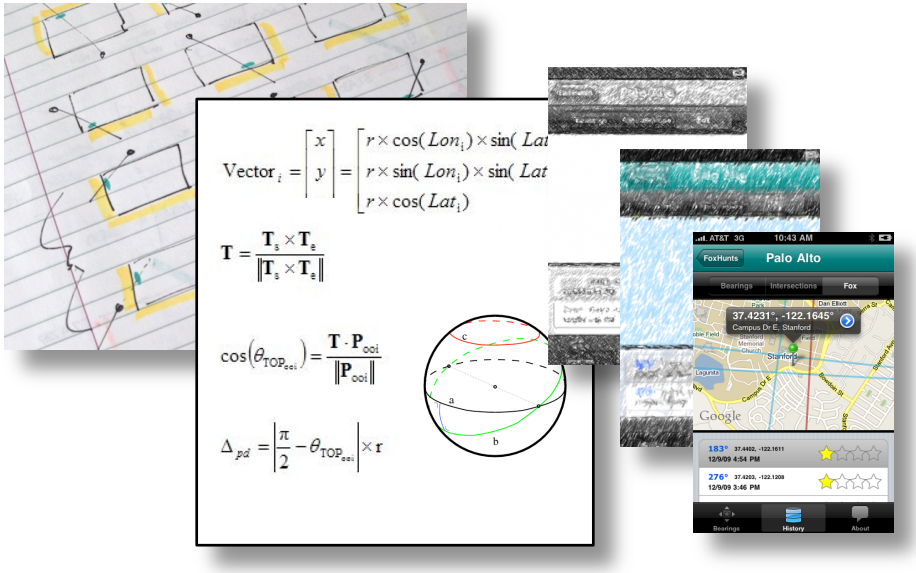
(personal project – joint with P. Iannucci)

- Goal: find a hidden transmitter using directional antennas, multiple bearings, and maps
  - Emergency first responders, DHS, FEMA, …
- Some view this as a sport
- My first attempt: "DNF"
  - So-so with the radio stuff
  - Failed at mapping and book-keeping

Motivated!

- A Good Engineer should be able to automate this
  - Make an app that does the book-keeping





App Completed

- Built, tested, released app in a few months
  - Handles the map and book-keeping
  - Uses iPhone built-in goodness: maps, GPS, compass, display, database
- Results
  - Today: in use in 74 countries
  - First responders, rocket trackers, otter spotters, swimming coaches, caregivers
  - "Positive Feedback"…
- … and then the Second System Effect set in
  - Idea: Add support for real-time sharing of info in teams
  - Idea: Develop a really fancy "wireless sensor" that does the hard RF work of determining direction-to-target

Result

- Several years later…
  - Device works! SDR, Doppler signal processing, RTOS, WiFi + USB support, smart LiPo recharger, onboard file system, syslog for field diagnostics, battery-backed RTC, wideband antenna switch, impedance-controlled PCB, low-noise layout, waterproof packaging, various Python dev tools…
  - New app plus bearing sharing cloud service just exited beta
- Do try this at home!

Conclusions

- History helps us determine the horizon so that we can plan to look beyond it
  - Mobile: software / services / selective HW
  - Connected embedded: search for the standard platform
- Challenge standing assumptions
- Mobile systems problems are close to the P's
  - Image understanding is particularly interesting
- Tackling the problems of scale is vital to having an impact in both domains
- Keeping your hands dirty is good for mental health!