CodeBlue: An *Ad Hoc* Sensor Network Infrastructure for Emergency Medical Care

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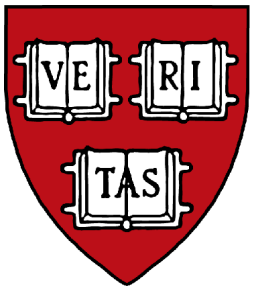


Mass Casualty Events

Large accidents, fires, terrorist attacks

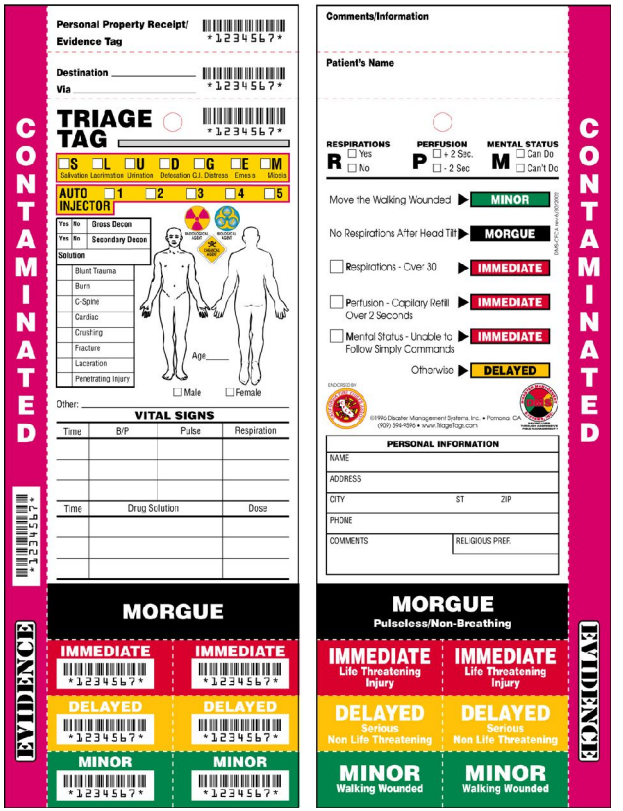
- Normal organized community support may be damaged or destroyed
- Large numbers of patients, severe load on emergency personnel

Manual tracking of patient status is difficult

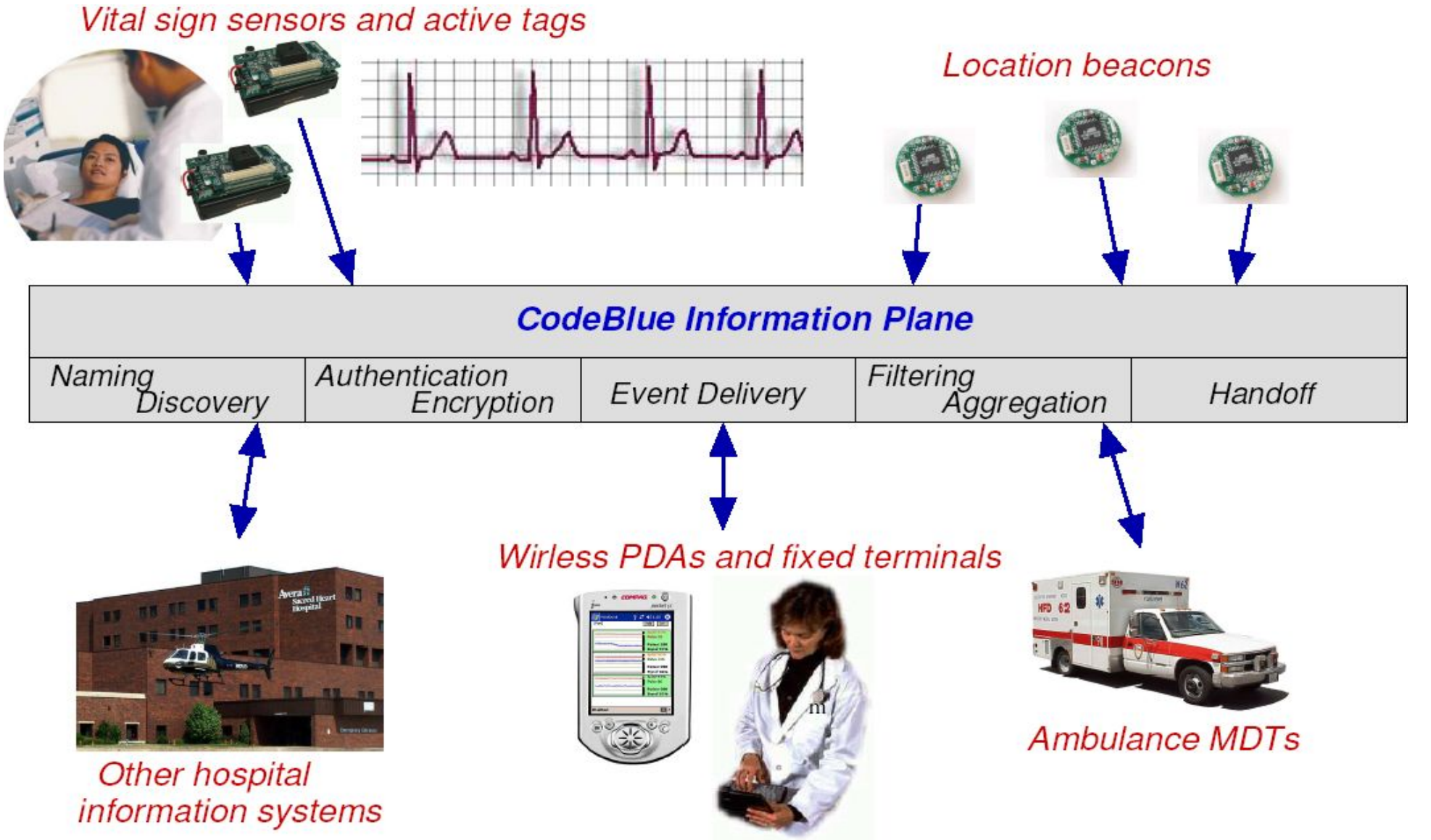
- Current systems are paper-, phone-, radio-based

Sensor nets have potential for large impact

- Real-time, continuous vital monitoring
- "Electronic triage tag" to store patient data
- Immediate alerts of changes in patient status
- Relay data to hospital, correlate with pt. records



CodeBlue Architecture



CodeBlue Architecture

Scalable, robust "information plane" for critical care

- Ad hoc, any-to-any routing with dynamic discovery of routes
- Runs across a range of devices, from motes to PDAs to PCs

Publish/subscribe data delivery model

- Sensor nodes publish vital signs, location, identity
- Rescue/medical personnel subscribe to data of interest
- In-network filtering and aggregation of data to limit bandwidth and information overload

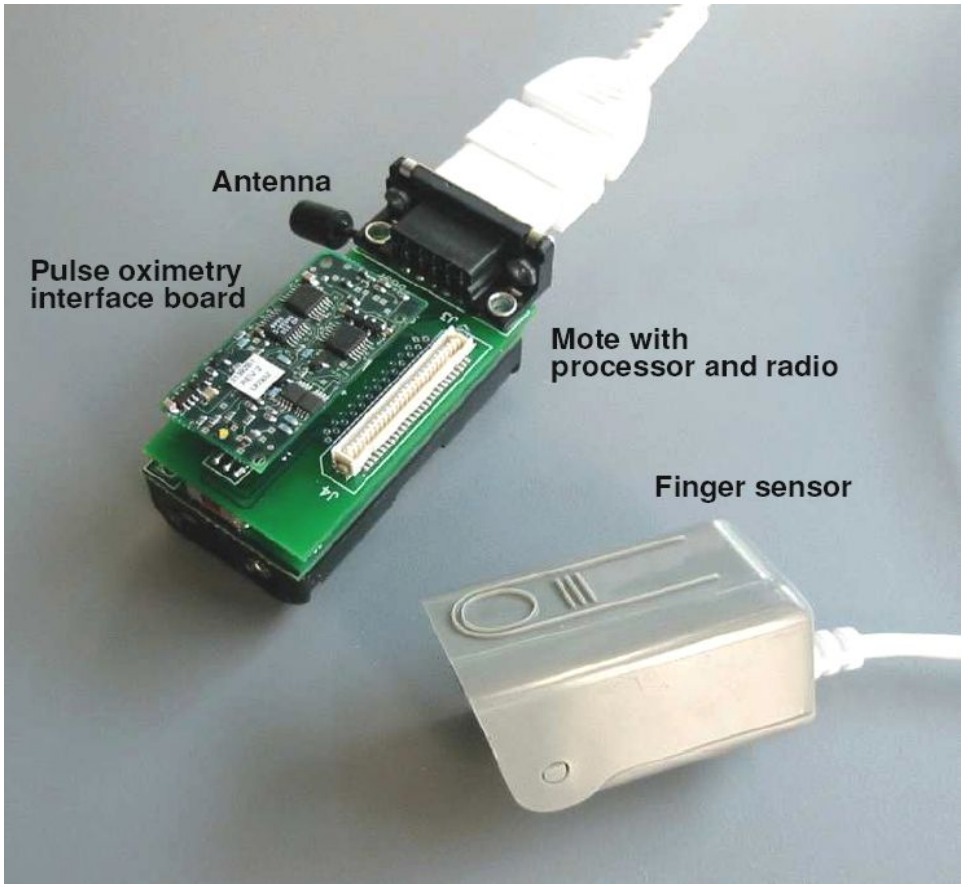
Reliable delivery of critical data

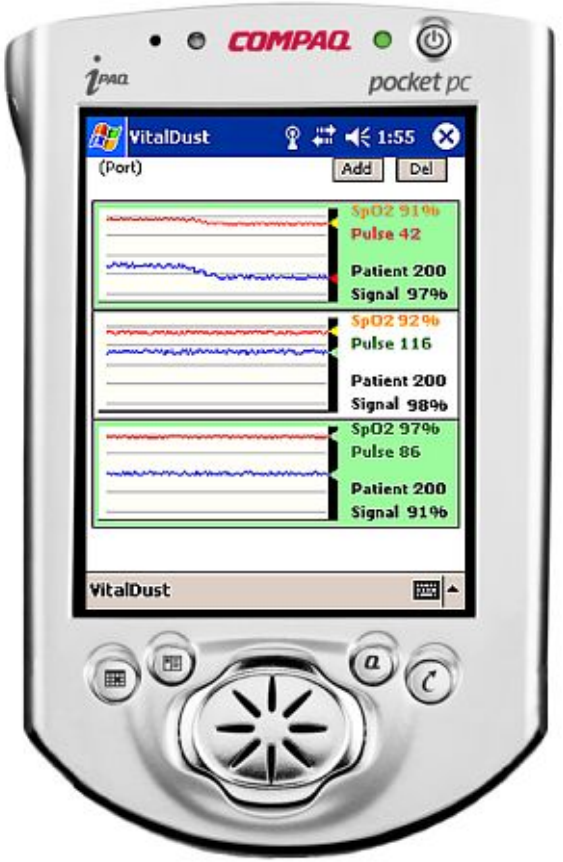
- Content-based prioritization
  - *e.g., patient stops breathing or loss of network connectivity*
- Scale transmit power to limit interference or issue "SOS" messages

Decentralized authentication and security

- Handoff of credentials across rescue personnel
- Seamless access control across patient transfers

VitalDust: Wireless vital sign monitoring





MICA2-based pulse oximeter using BCI, Inc. OEM board

- Measures heart rate, blood oxygen saturation
- Mote-based ECG currently under development
- PDA- and PC-based applications for multi-patient triage
- Integration with iRevive, PDA-based patient care record system for EMTs

Research Challenges

Scalable, flexible routing infrastructure

- Many existing ad hoc routing schemes are connection-oriented
- Much work in sensor networks focused on many-to-one data collection
- We require more flexible naming and pub/sub semantics

Rapid, robust, ad hoc deployment

- Must operate without external network or computational infrastructure
- Decision-making must be fully distributed
- Zero administrative overhead for setup and configuration

Coping with enormous ranges of density and node volatility

- Must scale to very high node densities
- Communication must adapt to widely varying network conditions

Lightweight, decentralized security mechanisms

- Sensor nodes are too primitive for expensive public-key approaches
- Still must support flexible security policies

Current Status

MICA2-based pulse oximeter using BCI, Inc. OEM board and EKG using custom-designed board

- Happy to share designs and hardware itself

PDA-based runsheets and pulseox software

Shared-key encryption and MAC layer based on SKIPJACK

Power-aware, multihop routing protocol prototype

Collaborations with Boston-area hospitals:

- Boston Medical Center
- Brigham and Women's Hospital

For more information:

- http://www.eecs.harvard.edu/~mdw/proj/vitaldust/
- David Malan <malan@eecs.harvard.edu>

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