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Outline

I. Pervasive Medical Monitoring

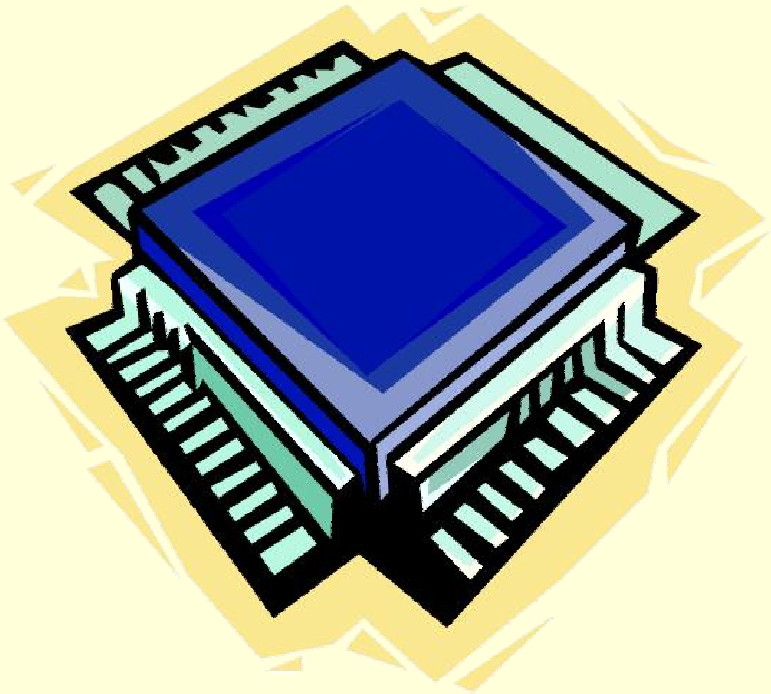
- What, Why, Why Now?

II. SMART Project

- Goals
- Architecture
- Operations
- Challenges

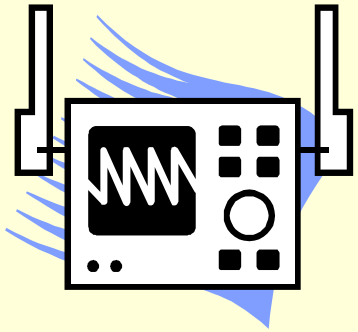
III. Evaluation

- Status
- Plans



What is Pervasive Medical Monitoring?

- Monitoring patients' vital signs in non-traditional contexts:
  - At home
  - At work
  - While exercising
  - While waiting for medical attention
- Access to patient information instrumental for making good decisions and taking action
  - Location
  - Vital Signs
  - Past medical history



Why Is Pervasive Medical Monitoring Important?

- Response time is critical
  - e. g., stroke, myocardial infarction
- Allows for increased outpatient care
  - Decrease length of hospital stay
- Increases patient independence
  - Increased mobility & control of environment
- Changing Demographics
  - More elderly, more people living alone
- Increases provider efficiency
  - Lower costs for all

Why Now?

- Advances in microelectronics make devices
  - easier to build
  - less expensive
  - lower power
  - lighter weight
- Advances in wireless technologies
  - 802.11 drove the wireless revolution
  - Bluetooth
  - Zigbee
- Patients and health care providers are familiar with information technology
  - Web

Ideal Elderly Care

- Patient: elderly woman
  - Debilitating multiple sclerosis
  - Lives at home with husband
  - Husband works during the day
- Situation:
  - Woman trips and falls, breaking her hip and losing consciousness
- Response:
  - At-home monitors notice she is lying on floor
  - Monitors notify her husband, EMTs and hospital
  - Hospital receives full vital sign history
  - Monitors continue to work throughout ambulance ride
  - Triage decisions are based on these data
  - Trauma team is ready for patient upon arrival
  - Husband arrives at hospital soon after patient

Pervasive Medical Monitoring Testbed: SMART

- Opportunity to deploy pervasive medical monitoring in Emergency Department of Brigham & Women's Hospital (Boston, MA)
- Controlled environment: test technologies before deploying in non-traditional settings.
  - In SMART, only patients with chest pains or respiratory complaints will be monitored
- Goal: develop infrastructure for increased use of pervasive medical monitoring.

Challenges: Emergency Care

- Excessive time spent in waiting room
  - 3 hour wait for medical care
- Difficulty finding patients, personnel and equipment when needed
  - over 50 beds in three units at BWH ED
- Understaffing
- Units must expand and contract
- Triage Priority System cannot account for changes:
  - Medical conditions can worsen in waiting room
- Too many uncoordinated alarms and alerts: sensory overload for caregivers

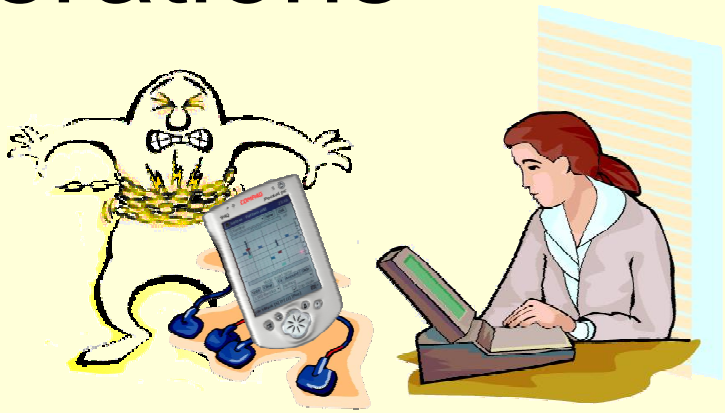
Waiting Room Emergencies

- Emphysema patient arrives at ED
  - Chief complaint: shortness of breath
  - Patient is likely not in serious trouble, receives triage status 3
    - But oxygen saturation level could fall, placing patient at imminent risk (status 1)
  - Respiration problems difficult to monitor by triage nurse
- Sensors can identify this problem easily.
  - Computers can alert triage nurse immediately

SMART Operations

1.

2.



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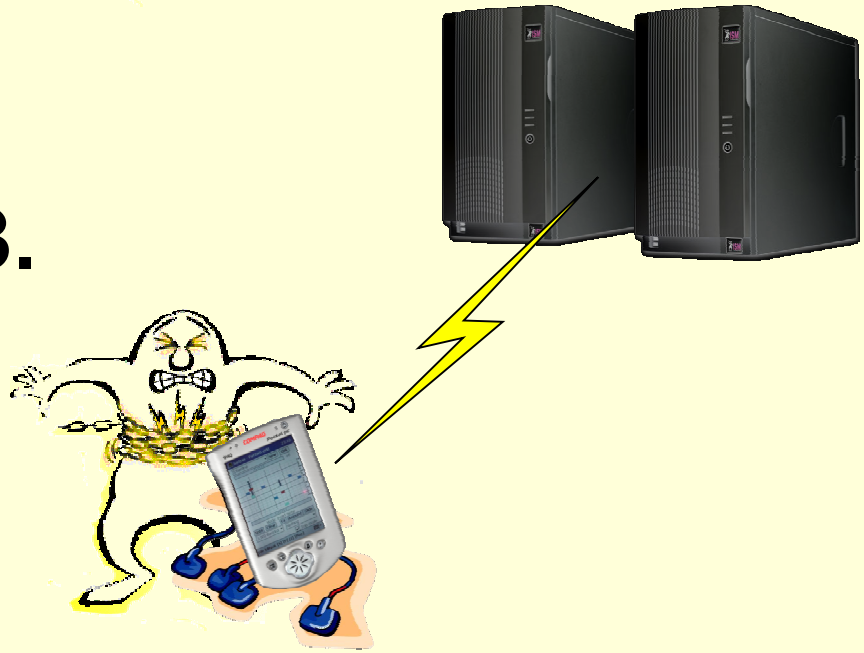

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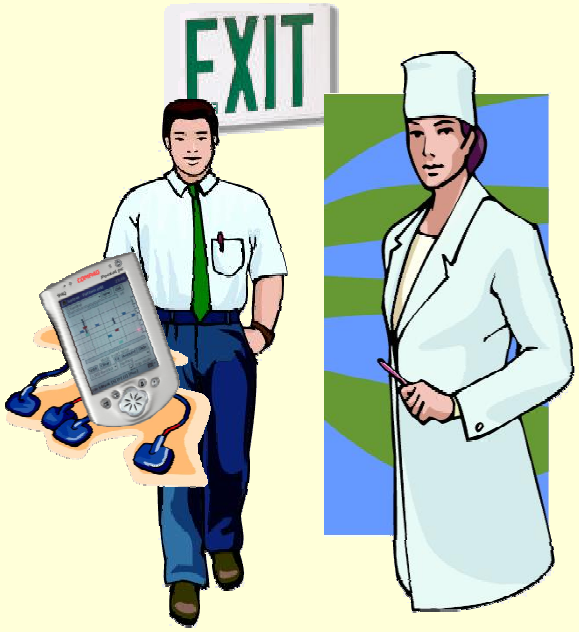
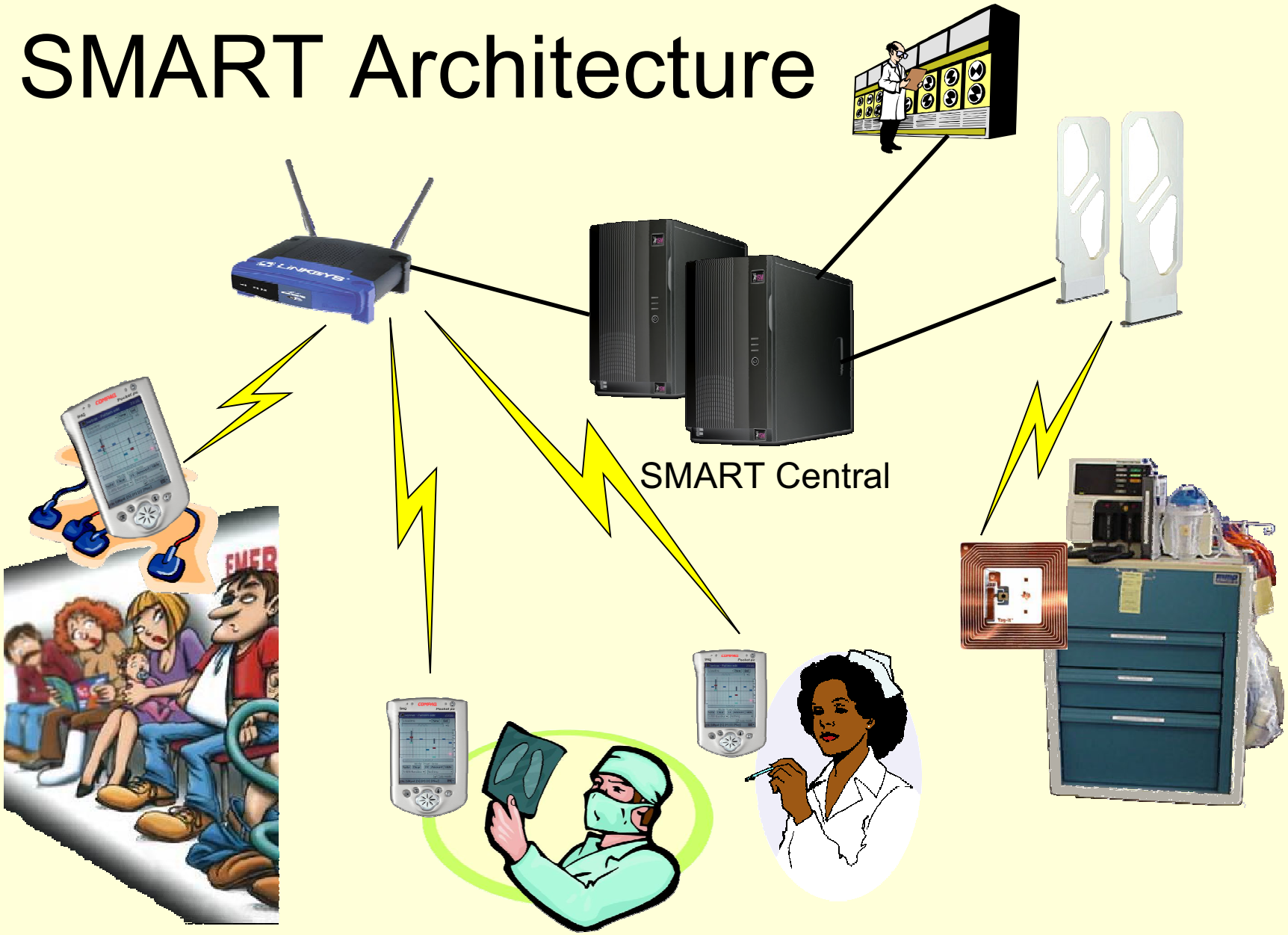


SMART Architecture



Challenges: Medical Sensors

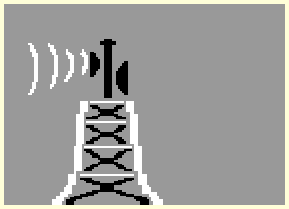
- Trade off quality data vs. price/weight
  - SMART must deal with noisy data
  - Sensors can fall off of patients
- Oximeter (SpO_2)
- 2-Lead ECG
- Other sensors: Respiration, Blood Pressure

Challenges: Location Sensors

- Cricket
  - Location determined at PDA
  - No extra wires required (for light powered cricket)
  - Requires extra accessories on PDA
- 802.11
  - Location determined by separate infrastructure
  - Extensive wiring required
  - No additional hardware needed at PDA
- RFID
  - For tracking equipment
  - Larger granularity
- GPS
  - Outdoors
  - In ambulance

Challenges: Managing Sensor Data

- Time stamping data from multiple sources
  - Synchronized clocks required
- Storing and retrieving continuous streams of data
- Dealing with noisy data from low-cost sensors
  - Motion artifacts: Patient movement can affect sensor readings
  - Gaps in waveform data: sensor falls off, patient walks out of range.



Challenges: Decision Support

- Integrate data from multiple sensors
- Recognize potentially dangerous medical conditions
- Allocate equipment and personnel to handle critical medical conditions
- Avoid broadcast alerts
- Re-prioritize patients according to present medical condition
- Integrate with current procedures
- Minimize false alarms
- Allocate decision support tasks between PDAs and SMART Central

Challenges: Privacy

- Must maintain patient privacy (HIPAA)
- Simple, flexible, consistent access control framework
  - Works across all SMART devices
  - Determines who sees what data
- Wireless encryption
  - Key distribution
  - Power consumption
    - Significant for the smallest sensors (motes)

Challenges: Scalability

- Dimensions of scalability
  - More patients
  - Bigger/Improvised ED
  - Use of technology in more settings
- SMART scales easily
  - SMART Central can be replicated
  - Addition of patient involves addition of PDA and associated processing power
  - Limited global interaction required for very large improvised care facility

Evaluation

SMART will be evaluated

by the medical community

based on tangible medical results:

- Improved response time for emergencies that develop in the waiting room?
- Improved triage priorities in waiting room?
- Improved Emergency Department (ED) operations during peak (overload) demand?
- End user acceptance?

Status

- Evaluating sensors
- Evaluating location systems
- Evaluating streaming databases

- Developing user interfaces
- Developing evaluation study
- Obtaining Institutional Review Board approval

Plans

- Deploy in laboratory environment by end of summer 2004
- Deploy in limited scale at BWH ED in a small number of patients by summer 2005
- Deploy in all eligible patients at BWH ED from Sept 2005- August 2006
- Extend to Ambulances, 2006
- Plan for Mass Casualty Events

Acknowledgement

UNITED STATES
National Library of Medicine

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