



Patient Monitoring System using Wireless Sensor Networks



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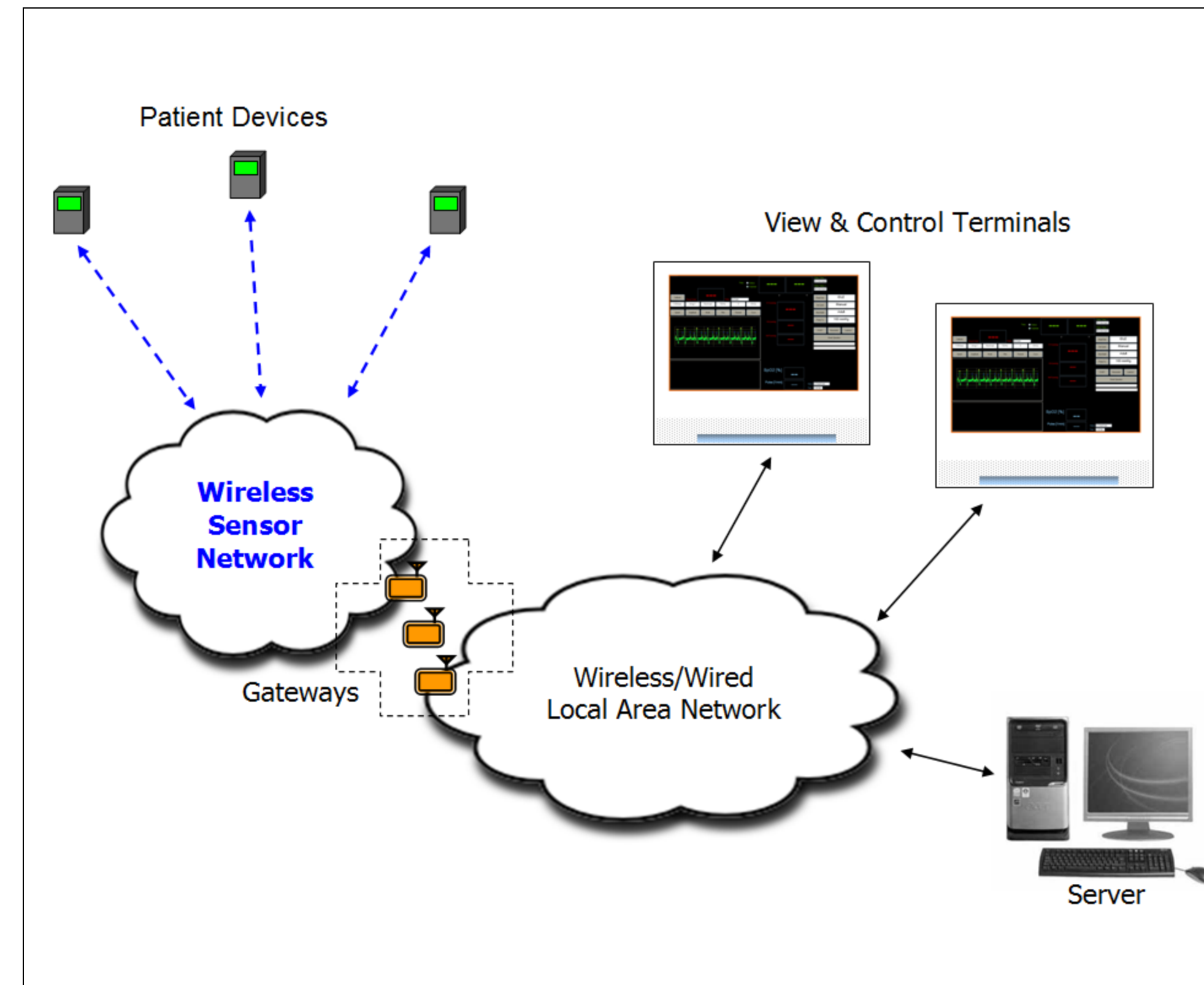
Abstract

This work designs and implements an advanced patient monitoring system capable of offering functionalities and performance of a conventional patient monitor while allowing patient's mobility, 360-degree access, convenient and fast transfer.

Patient's vital signs including blood pressure, pulse oximetry, ECG and body temperature are tracked continuously. Medical data is processed in real-time to identify emergency situations and trigger actionable responses.

The developed system aims to enhance patient care quality of service, improve hospital workflow efficiency, and save time and costs.

System Architecture



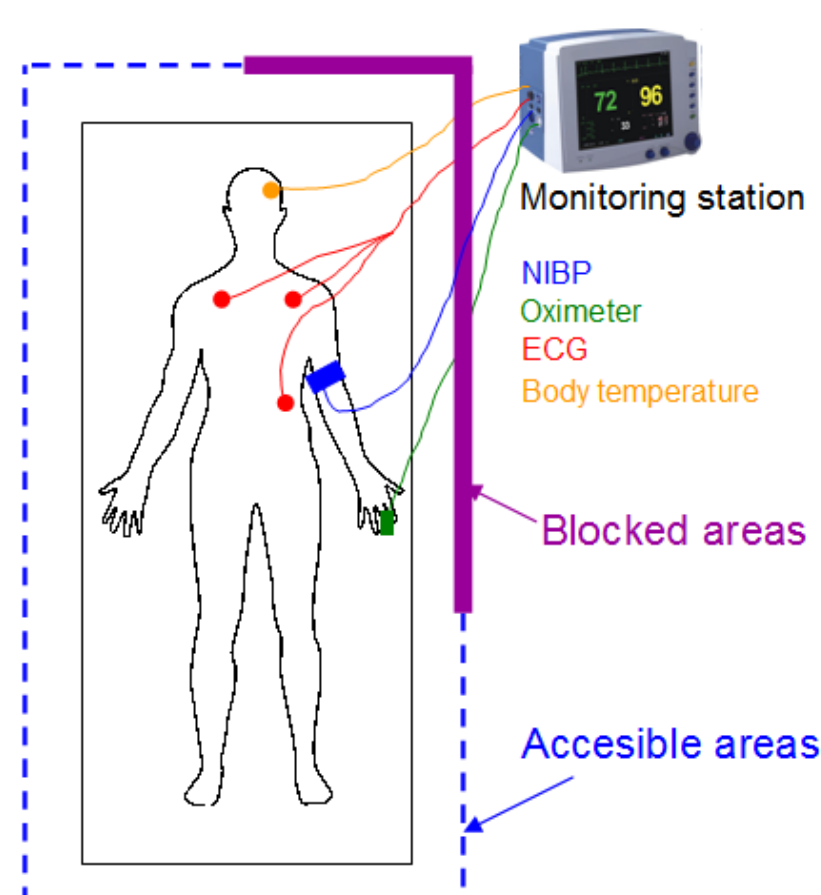
Wireless Routing Protocols

Protocol	Summary
Fixed Routing	Next hops for (s, d) messages are given in advance by fixed routing tables
Broadcasting	No network state information is required; Messages are simply re-broadcasted by each node
Flooding Routing	Similar to broadcasting, however, messages are selectively re-broadcasted by each node
Gossip Routing	One-hop neighbor information is required; Next hop is a randomly selected neighbor
Geographic Routing	Node location information is required; Next hop is the neighbor closest to destination
EMI-Aware Dynamic Routing (*)	Distributed routing framework; One-hop neighbor information is required; Next hop is the neighbor currently generating the least Electro-Magnetic Interference (EMI) level
Hole-Avoidance Geographic Routing (*)	One-hop and two-hop neighbor information is required; Next hop is the neighbor with the highest weight value representing distance to destination and connection diversity
Energy-Efficient Convergecasting with Multiple Collectors (*)	Collectors advertise their presence by periodical hello messages; Routers approximate their distances to each collector; Messages are autonomously flooded towards the closest collector over energy-efficient paths

(*): protocols that have been developed and experimented by this work

Conventional Patient Monitor

- Vital signs of patients in emergency areas are currently measured by wired and non-movable monitoring stations
- Emergency areas are quite crowded with many patients and equipments



Disadvantages:

- Many wires btw. the patient and the monitor
- Medical staff cannot access patients easily due to wire blocking
- All probes need to be detached and re-attached on move
- Monitoring station is generally fixed at some location

- How to deal with those disadvantages in order to increase the workflow efficiency and to improve the patient care quality of service?

• Patient Device (PD)

- A portable device that can be attached to a stretcher or carried by a patient (one PD for one patient)
- Monitors patient's vital signs: Non-Invasive Blood Pressure (NIBP), Pulse Oximetry, Electrocardiography (ECG), Body temperature
- PDs form the Wireless Sensor Network (WSN)

• View & Control Terminal (VCT)

- A networked PC/wireless laptop/Wi-Fi-enabled device
- Displays medical conditions of any patient of interest
- Remotely controls/configures PDs (start/stop/set meas. mode, ...)

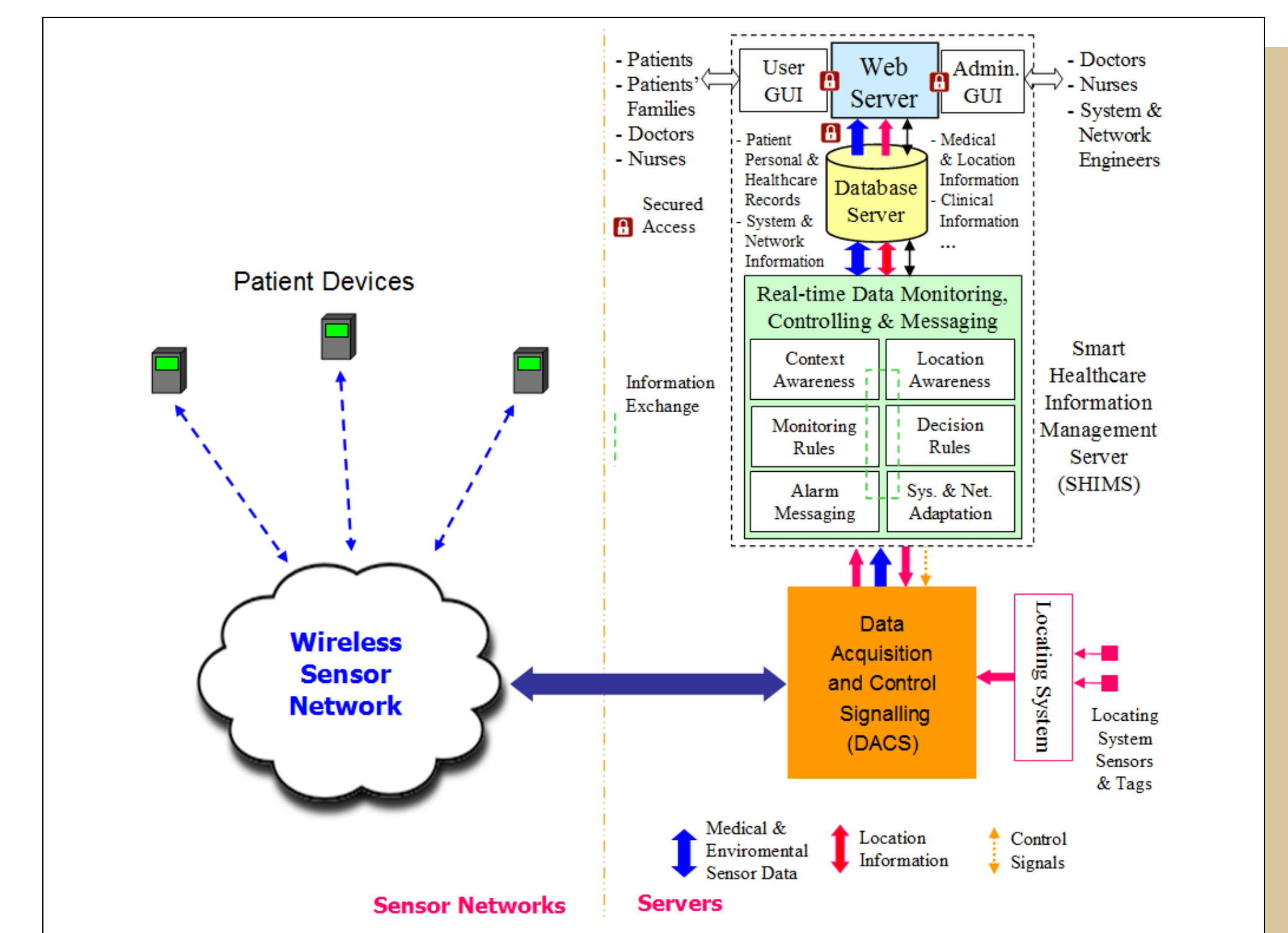
• Gateway

- Interconnects WSN with hospital's LAN (Server, Remote Terminals)

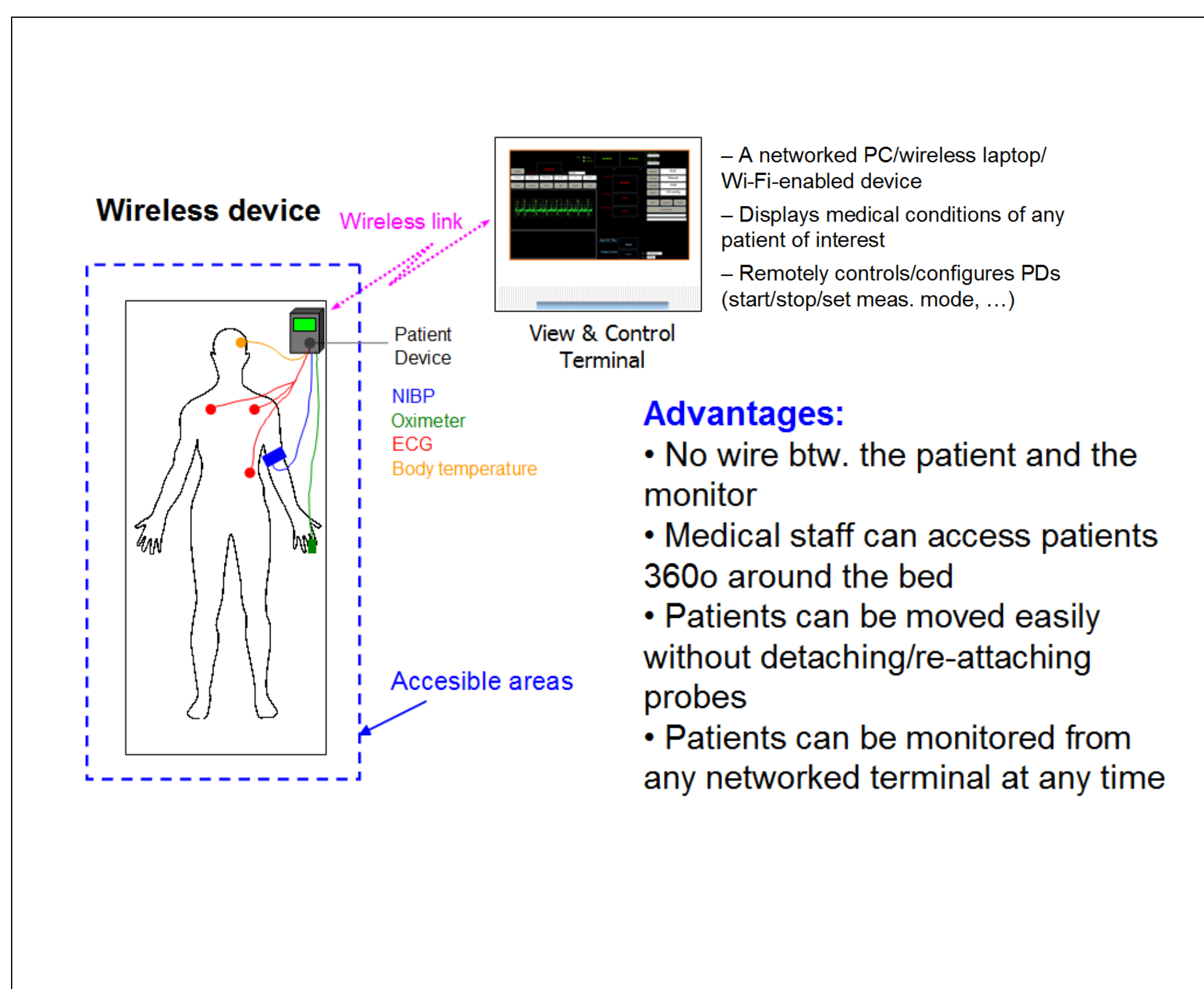
• Server

- Database server of the whole system
- Relays medical data and control signals between PDs and VCTs

Data Flow & Software Design



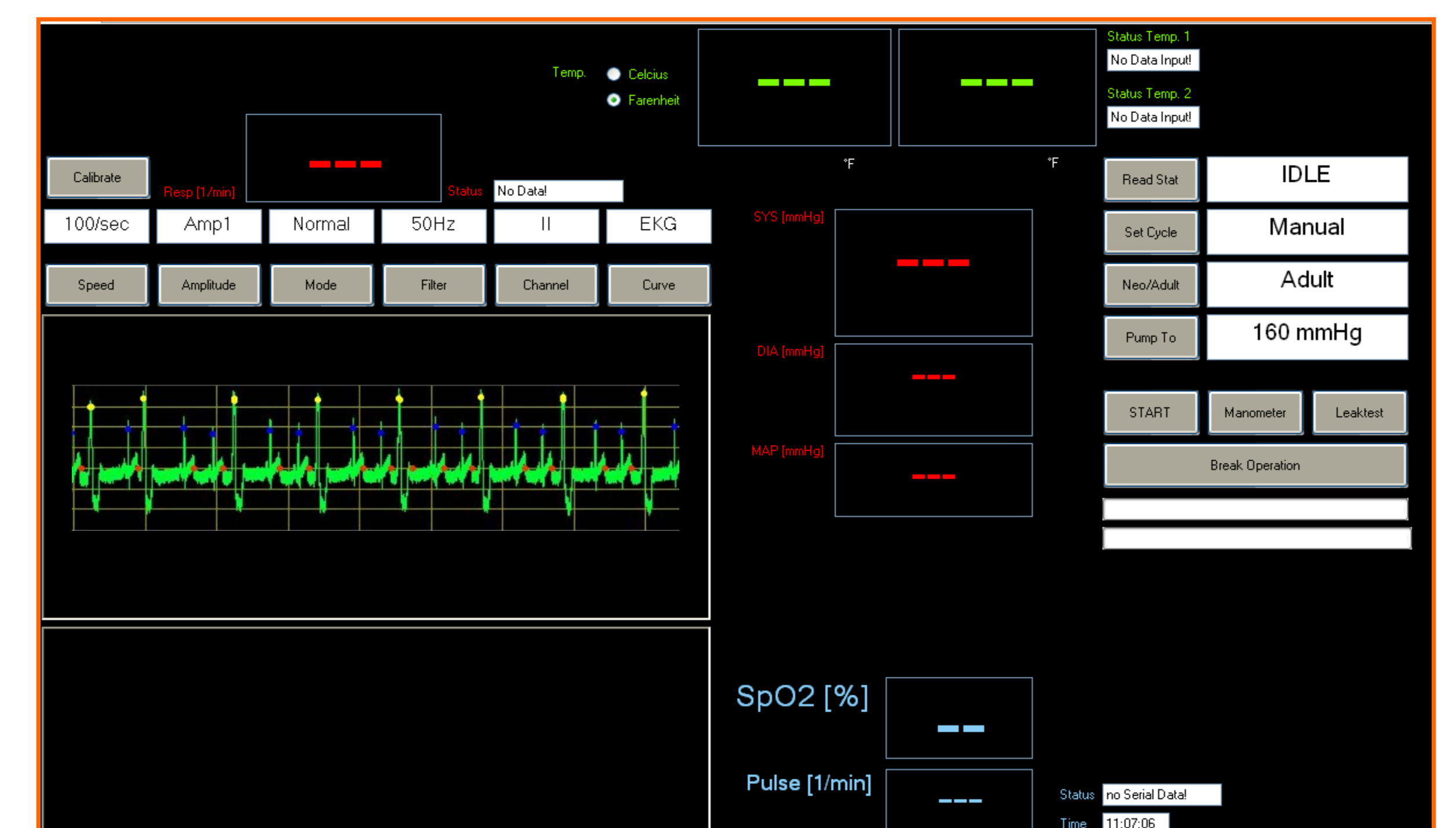
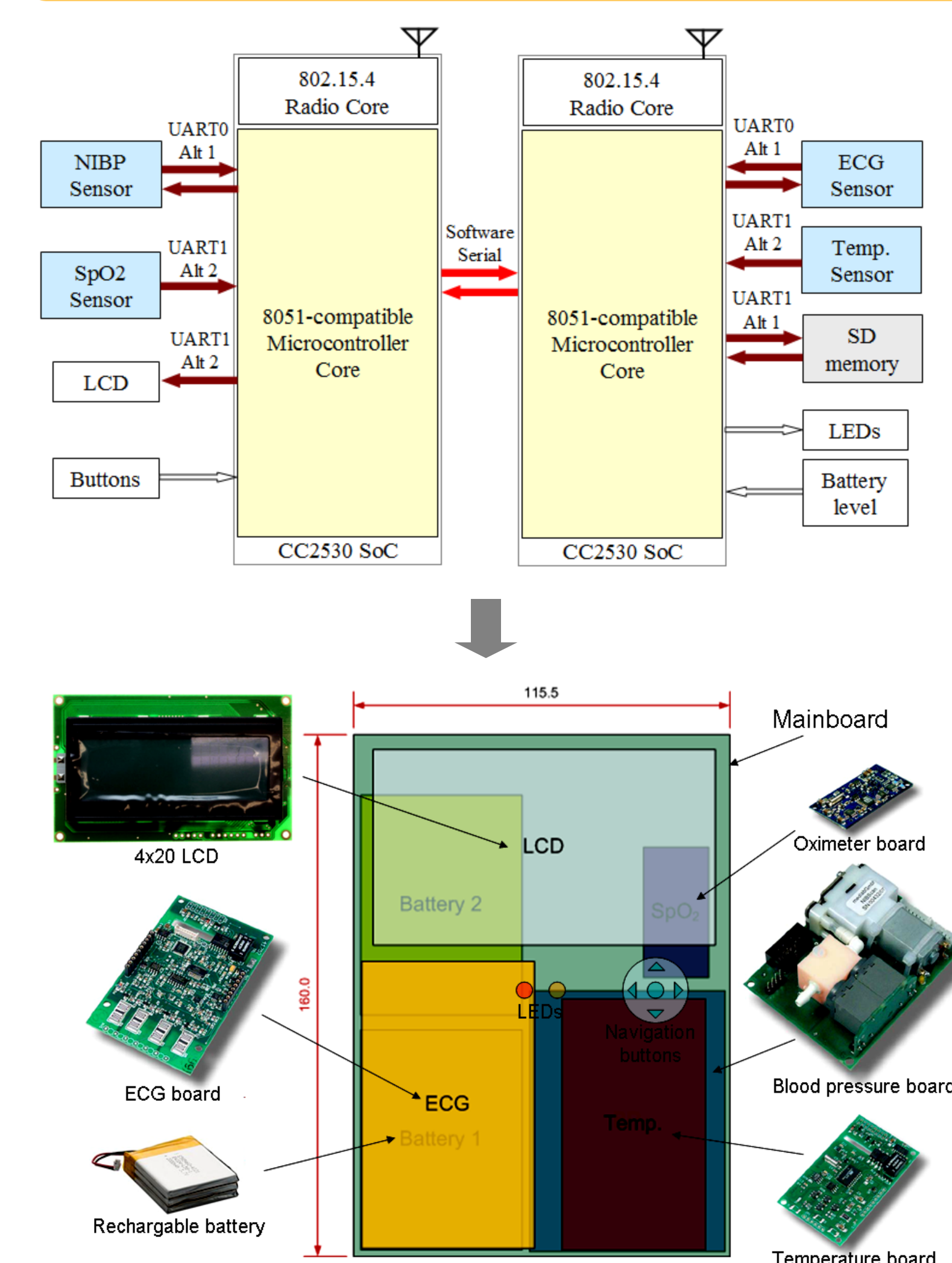
Wireless Patient Monitor



Advantages:

- No wire btw. the patient and the monitor
- Medical staff can access patients 360o around the bed
- Patients can be moved easily without detaching/re-attaching probes
- Patients can be monitored from any networked terminal at any time

System Design & User Interfaces



Interface at View & Control Terminal

Operation/configuration of medical sensors can be also controlled/setup by Patient Device's navigation buttons & menu displayed on LCD

Blood pressure:

- Start measurement
- Stop measurement
- Leak test
- Set Cycle: Manual; 5 min; 10 min; 20 min; 30 min
- Neo/Adult: Neo; Adult
- Pump to: 120 mmHg; 140 mmHg; 160 mmHg; ...

