Distributed Prognostics

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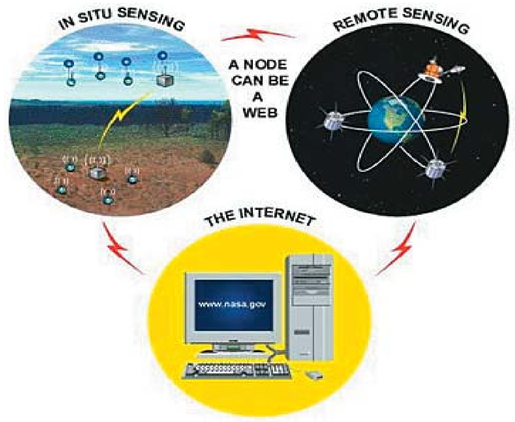
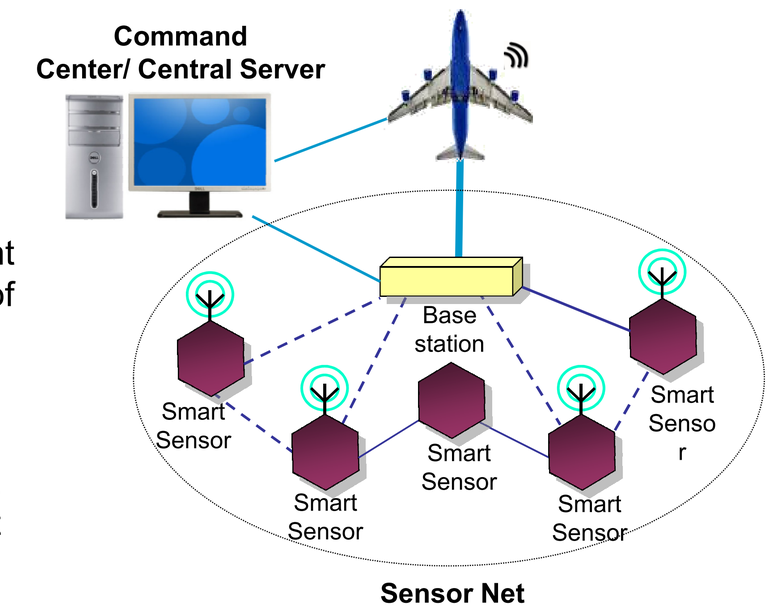
Overview

Motivation – The Sensor Web



- The Sensor Web was conceived at the NASA/JPL in 1997
- It is a macro-instrument comprising a number of sensor platforms/pods (orbital or terrestrial, fixed or mobile).
- The purpose is to extract knowledge from the data it collects and use this information to intelligently react and adapt to its surroundings.

Distributed Health Management



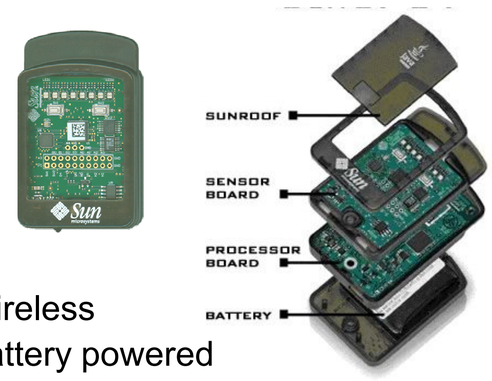
Why distributed?

- Current prognostics health management systems envision a centralized architecture for implementation
- Drawbacks
  - –Performance issues
    - –Throughput decreases for computation and memory intensive systems
    - –Cannot handle heavy multi-tasking
  - –Lack of robustness
    - –Failure in a main hub can shut down entire system
  - –Restricted scalability
  - –Poor resource utilization

An integrated network of sensors could monitor not only structural elements, but also the health of electronics, hydraulics, avionics, and other systems.

Methodology

Wireless Smart Sensor Device (Sun SPOT)



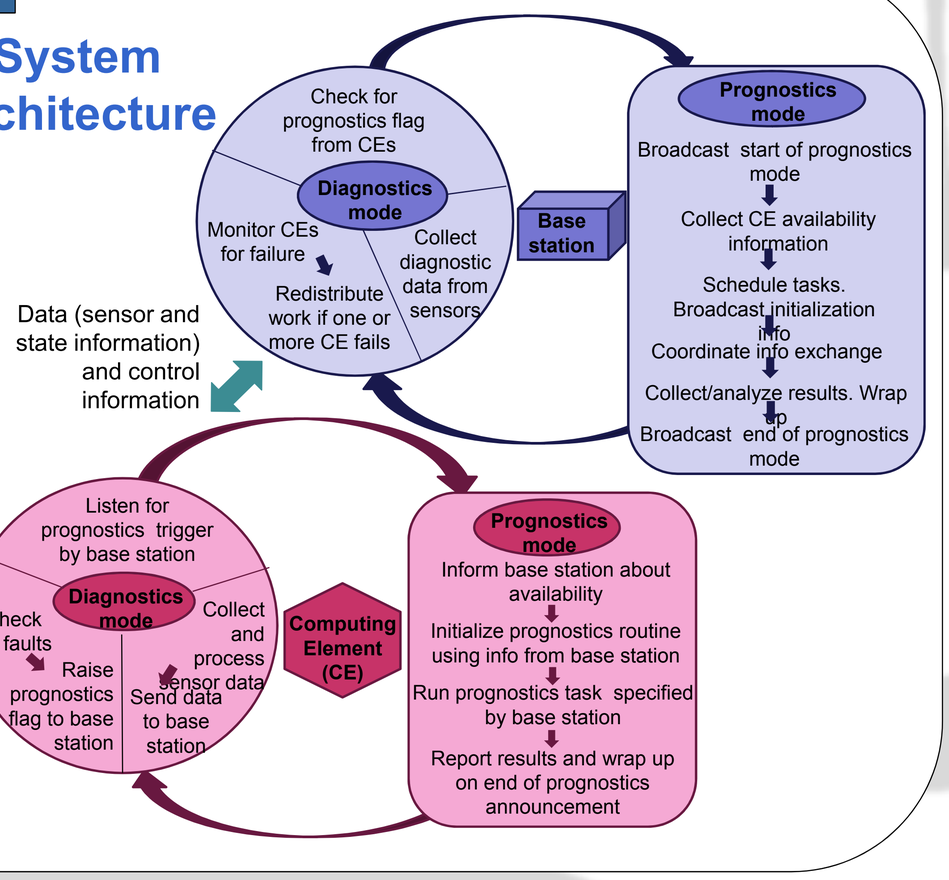
- Wireless
- Battery powered
- Powered by 32bit ARM7 processor
- Onboard sensors include temperature sensor, light sensor and accelerometer
- Provision for external sensors
- Software
  - –Java Virtual Machine

www.sunspotworld.com

Experimental Details

- *Computing Element (CE)* is a smart sensor device in our experiments
- One of the SunSPOT devices is used as a base station which is connected to laptop via USB
  - The base station is not fixed and determined during execution
- Experiments with 2 and 3 SPOTs with one as base station and rest free as CE
- Sensor information from history and other initialization information were read in via USB from laptop and communicated to CEs
- Main design problem
  - Restrictions due to communication message length imposed by the device

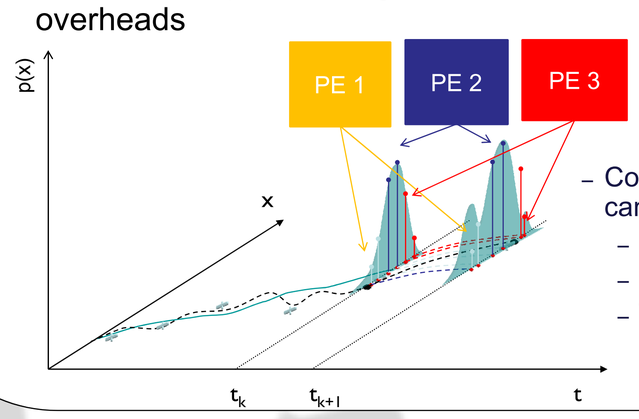
System Architecture



Results

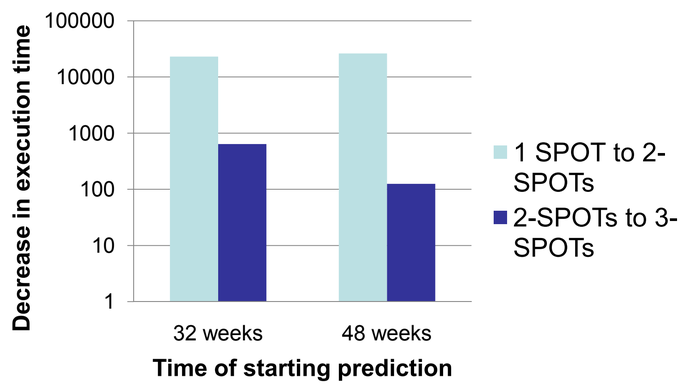
Application Domain

– Particle filter based prognostics for rechargeable Li-ion batteries
  – Computationally challenging for centralized processing architecture
  – Particle operations have significant scope for parallelization
  – Resampling provides opportunity to investigate tradeoffs between computational gains and communication overheads



– Computation steps that can be distributed
  – Sampling
  – Propagation
  – Weight update

System performance



Static program memory usage of SPOT devices
–Free range SPOTs: 29KB
–Base station: 101KB

Observations

– Significant amount of time is spent in wireless communication
– Low program memory utilization of SPOT devices indicate that more multi-tasking can be achieved

Future Work

– Design of efficient distributed resampling algorithms
– Exploration of other prognostics algorithms such as GPR (Gaussian Process Regression)

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