National Aeronautics and Space Administration

Distributed Prognostics and Health Management with a Wireless Network Architecture

NASA has developed a method that prevents total system failure during emergencies, allowing parts of the system to continue to function, and making overall system recovery faster.

A heterogeneous set of system components monitored by a varied suite of sensors and a health monitoring framework has been developed with the power and flexibility to adapt to different diagnostic and prognostic needs. Current state-of-the-art monitoring and health management systems are mostly centralized in nature, where all the processing is reliant on a single processor. This requires information to be sent and processed in one location. With increases in the volume of sensor data as well as the need for associated processing, traditional centralized systems tend to be somewhat ungainly, in particular, when faced with multitasking of computationally heavy algorithms. The distributed architecture is more efficient, allows for considerable flexibility in number and location of sensors placed, scales up well, and is more robust to sensor or processor failure.

This technology is available for licensing from NASA's space program to benefit U.S. industry.

Technology Details

The distributed health management architecture is comprised of a network of smart sensor devices. These devices monitor the health of various subsystems or modules. They perform diagnostics operations and trigger prognostics operation based on user-defined thresholds and rules. Both the diagnostic and prognostic tasks are formulated as a particle-filtering problem for state estimation and remaining life estimation, which also allows the explicit representation and management of uncertainties (but other suitable algorithms can also be used). The sensor devices, called computing elements (CEs), consist of a sensor, or set of sensors, and a communication device (i.e., a wireless transceiver) beside an embedded processing element. The CEs can run both a diagnostic and prognostic operating mode. The diagnostic mode is the default mode where a CE monitors a given subsystem or component through a "low-weight" diagnostic algorithm. If a CE detects a critical condition during monitoring, it raises a flag. Depending on availability of resources, a networked local cluster of CEs is then formed that carries out prognostics and fault mitigation by efficient distribution of the tasks. The CEs are expected not to suspend their previous tasks in the prognostic mode. When the prognostics task is completed, and after appropriate actions have been taken, all CEs return to their original default configuration.

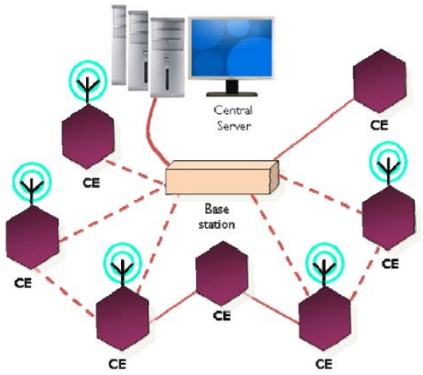
When the distributed implementation is coupled with wireless technology, the overhead related to weight and cost of wired systems (in either centralized or distributed configuration) is not present.

Patent

This technology is protected by a pending U.S. Non-Provisional Patent Application. (Reference No. ARC-16450-1)

Benefits

- Prevents total system failure during operations
- Allows for flexibility in sensor placement
- Allows for more sensors to be deployed
- Faster execution time of the prognostics algorithms
- Distributed architectures are more robust with regard to recovery from node failure



The sensor devices called computing elements (CEs)

Commercial Applications

- Prognostic Health Management
- Commercial Aerospace and Aircraft
- Mechanical Systems
- Process Industries

Contact the Ames Technology Partnerships Office at 1-855-627-2249 or ARC-TechTransfer@mail.nasa.gov