WHITE PAPER

Achieving Reliability to Match Capability

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Achieving Reliability to Match Capability

Each new defense platform asks more from embedded electronics. Designers respond with faster processors, more processors, more sensors, and faster interconnects These leaps in embedded capability carry with them expanding complexity. Every new component is another potential point of failure. What does that do to mission reliability?

System engineers wrestle with the problem.

Some are building their own solutions, writing software to collect component information and then make sense of what is collected. Veteran engineers, who have been down the roll-your-own road before, know its pitfalls and would much prefer a standards-based, flexible, and rigorously tested solution focused on maintaining embedded system reliability.

Abaco recognized the need and went to work. The result was Health Toolkit.

Introduction

Health Toolkit is a software package focused on monitoring the operational health of all components within an embedded system. It collects data on temperatures, voltages, storage capacity, bus usage, and virtually any other parameter that can be measured, all with a high degree of granularity. The Toolkit then reports that information to users and shares it with other applications, identifying potential problems, high risk situations, and impending failures.

Standards-based and Flexible

The Health Toolkit's functions start with a 'health inspector' software agent, running on a platform CPU, that collects information from processing boards, networking cards, memory modules, and other components throughout a system. This collected information includes processor and board level temperatures, CPU utilization, memory utilization, sensor performance, power status, voltage levels, and network interconnect usage.

The information is then published onto the internal network by open standard Data Distribution Service (DDS) middleware (see sidebar), using a data model optimized for system health applications. Within an OpenVPX system, that internal network can be RapidIO, PCI Express, or Etherent. For a platform-level system-of-systems, Ethernet is a common network choice, though DDS flexibility supports a range of other options. The published system health information can even go beyond an internal, platform-level internal network and onto a wider IP network or 'cloud', using terrestrial RF communications or satellite links.

Data Distribution Service

The Data Distribution Service (DDS) is an Object Management Group open standard for middleware. It defines a publish/subscribe model for delivering and receiving data, offering the advantage of decoupling communications between publishing and subscribing applications. DDS handles message delivery, using a clearly defined data model.

DDS supports well-defined interfaces between components, subsystems, and applications, replacing stove-piped, closed, and proprietary architectures. It standardizes messaging semantics that reduce development and integration costs while improving system scalability and robustness.

The Health Toolkit uses RTI's Connext DDS implementation, which is widely used in the Military and Aerospace market. Connext DDS is designed for the Industrial Internet of Things (IioT), allowing applications to exchange data in real time and providing the non-stop availability and security essential for mission-critical systems. It has proven success in thousands of mission-critical systems including autonomous vehicles, connected medical devices and next-generation energy systems.

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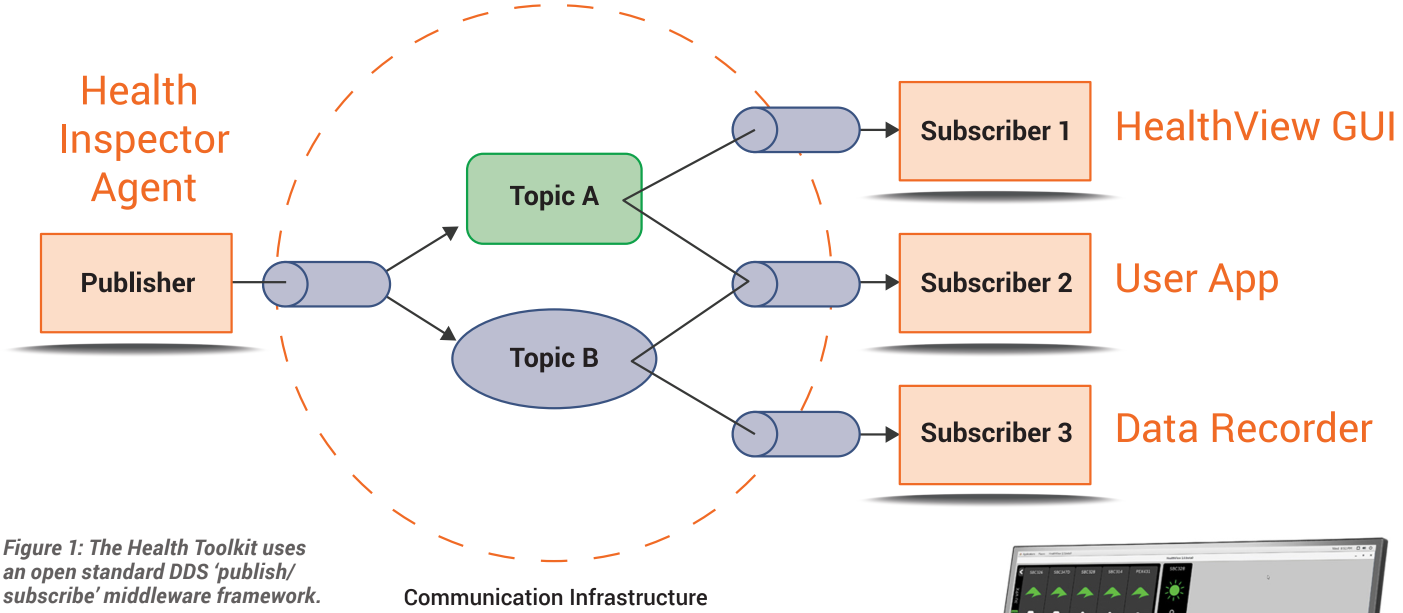

Figure 1: The Health Toolkit uses an open standard DDS 'publish/ subscribe' middleware framework.

Implementing a DDS 'publish/subscribe' model, the health information is available for user display, storage for future analysis, and as input to user applications.

- Health Toolkit includes a HealthView GUI application (see sidebar) that serves as an interactive system health dashboard, displaying up-to-date information on easily-understood screens. The same live information can also be displayed on any common web browser via the Toolkit's web server.

- Simultaneously, the information can be recorded as a database for future analysis.

- Most importantly for system reliability, the collected system health information can be input to one, or more, user applications. These applications can interpret the real-time data and compare it with historical data, then make smart decisions and take appropriate action to maximize system reliability and availability.

The HealthView GUI Dashboard

Figure 4: The HealthView GUI dashboard displays a summary on system components in the top section, with the lower section showing more detailed information for selected components.

A key part of the Health Toolkit is the HealthView dashboard, delivering an interactive and intuitive view into the published health data. On the top is a summary of all the components in the system; the bottom section shows a more detailed view of the information available for each component. In this detailed section, users can easily drill down into the information categories for each component – for example, temperatures, voltages, CPU utilization and memory utilization in a specific SBC. Users can also view information on connected sensors as well as basic board level information.

Abaco Software Solutions

The Health Toolkit is a further extension of Abaco's growing family of software solutions. Abaco's middleware is enabling our customers to leverage the power of data, allied with advanced software technologies, including AI, deep learning and software-defined machines, and combining these to deliver actionable insights either via a GUI or an API. Other middleware products include:

- AXIS Software Development Tool Suit, an integrated tool set that reduces the time to develop, test, debug, and optimize complex software applications. It supports heterogeneous multiprocessor CPU and GPU platform architectures.

- OpenWare™ Network Management Software, Abaco's switch management environment, available for Ethernet switches. It provides users with switch control routing and protocol implementations, delivering a switch that can be easily configured for any environment.

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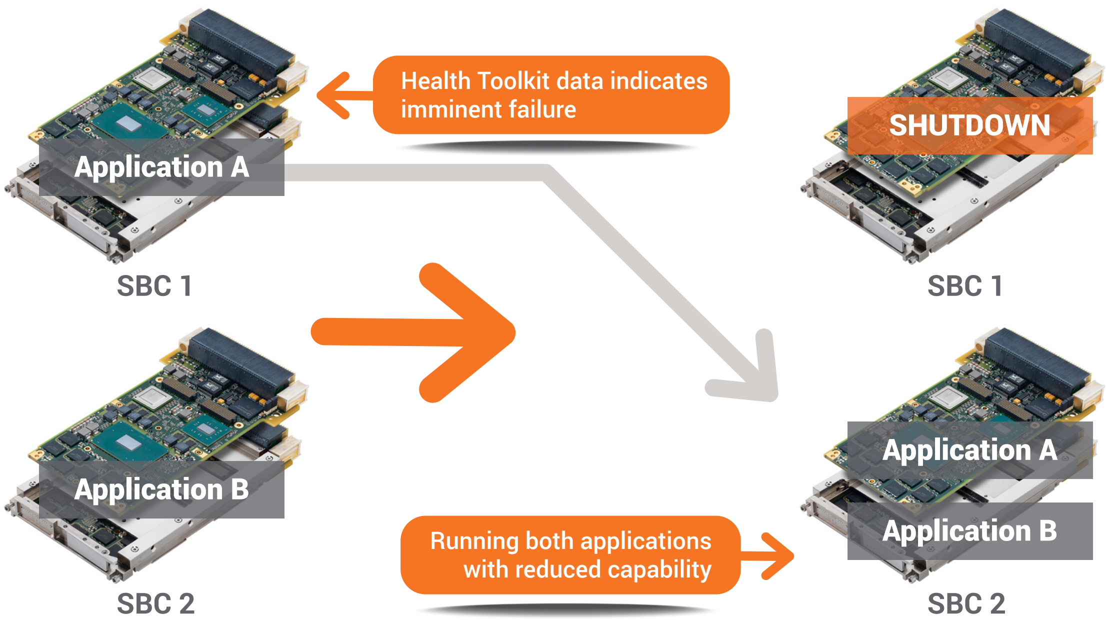

Figure 2: Failover and application reallocation

Able to Keep the Mission Alive

A few currently deployed embedded systems support in-mission failover after failure, so that if a processing component fails, an application running on that component can be restarted on one with a similar architecture. The Health Toolkit can certainly be used to support that type of failover, but the unavoidable fact is that the application will not be running for some period of time, with potentially serious implications.

Health Toolkit enables a superior capability. If the information collected by the Health Toolkit indicates an imminent failure in a processing component (SBC or even a single CPU), an application can reallocate tasks from that component to other components, while the system is running.

For example, imagine a 3U VPX system in a small platform with 2 identical SBCs, one handling radar processing and the other controlling the user interface and displays. If Health Toolkit detects that one SBC is about to fail, an application can reallocate both functions to the other SBC, accepting some reduction in capability, such as a reduced number of radar targets tracked. Or, in a larger system example, suppose that in a high resolution ground imaging SAR system, using multiple processors, Health Toolkit detects that one processor is about to fail. Reconfiguring to run without that processor keeps the mission alive, but with reduced area coverage by the SAR imaging.

These types of reallocation applications are clearly mission specific and need to be developed based on an understanding of that mission, the platform, and the processing system. However, the Health Toolkit comes with example code showing how a reallocation application can be developed using data collected and published over the network by the Health Toolkit. These examples, combined with a fully documented data model, give developers a solid foundation for integrating their applications into the Health Toolkit framework.

Working with Built in Tests

Health Toolkit works seamlessly with all styles of Built in Tests, maximizing their benefits for system reliability and availability.

Power-on Built in Test (PBIT) is widely used to determine if a system is performing properly before loading the primary embedded application. This is often simply a pass-fail test, so a platform's mission is scrubbed if a critical system fails its PBIT. Health Toolkit can expand a mission's range of options by providing a reliability application with detailed data about component health so that reconfiguring choices can be made and mission availability preserved.

Continuous Built in Test (CBIT) is a non-intrusive, low-utilization test that runs throughout a mission in the system background. Initiated Built in Test (IBIT) is a test that is started by a user, or another application, because of a detected or reported system event, for example, a reported error code. With Health Toolkit, CBIT and IBIT results become part of the collected health information, which can be stored, displayed, and used for availability decisions.

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Open, for an Extended Reach
Because DDS is an open standard, the Health Toolkit not only collects and reports on data from Abaco VPX hardware, it also delivers the same capability for third party and custom hardware. It functions as a single agent, using a set of interfaces to gather information from multiple boards in a VPX chassis. See Table 1.

DATA TYPE	INTERFACES
Temperatures	IPMI and Operating System
Voltages	IPMI
PBIT results	IPMI
CBIT and IBIT results	Dedicated API
CPU, memory, and disk usage	Operating System

Table 1: Health Toolkit data collection in VPX systems

Even beyond DDS-supported networks and interfaces, if the CPU hosting the Health Toolkit has a connection to some other communication structure, such as CANbus or 1553 bus, then information can be sent to that CPU and added to the Health Toolkit data base independently from the Health Inspector Agent.

At Abaco, we are continuing to evolve all our system components – hardware, firmware, and software – so we can better address system health monitoring and data collection requirements. Looking into the future, the Health Toolkit could be used to monitor the overall system health status of UAV or UUV swarms, as long as there is a data link from each individual unit in a swarm to the CPU hosting the Toolkit.

Also, as Artificial Intelligence (AI) implementations mature, AI-enabled applications will be able to extract predictive information from complex sets of system health historical data archived by the Health Toolkit. Linking in insights from Big Data analytics will open other avenues to extending system availability and reliability.

Added Value During Development and After the Mission
Beyond its critical mission support advantages in a deployed platform, the Health Toolkit delivers important value during system development. Engineers can monitor a complete set of system components during all stages of testing, so they are aware of more than just obvious failures but also of parameters, such as temperatures or voltages, that are trending into ranges that indicate potential failures.

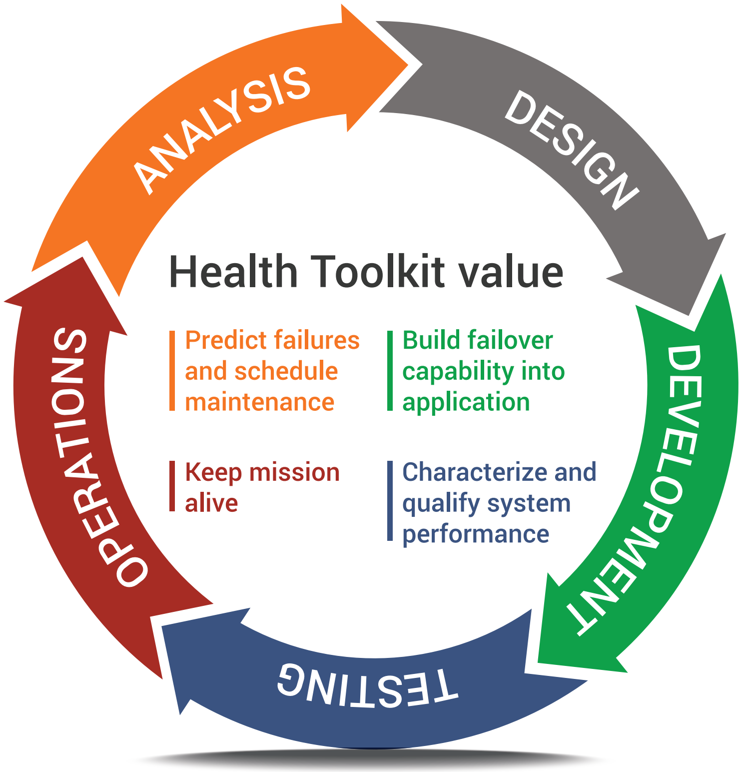

Figure 3: The Health Toolkit delivers value for test, operations, and analysis.

Monitoring system health information continuously during rigorous rounds of ‘shake and bake’ testing will allow design issues to be pinpointed, including the complex interactions between components as environmental stresses gradually degrade system performance and integrity. A data base of stored information, built by the Health Toolkit, will also be able to provide useful evidence of successful testing. For example, a graph of all temperature sensor values in the system over the duration of a successful environmental test would clearly demonstrate deployable system viability.

In addition, engineers and support personnel will be able to review the Health Toolkit’s collected data after a mission, comparing it with a data base for information for the same or similar platforms. Statistical relationships will be identified and used to facilitate preventive maintenance thru predictive analytics.

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Engage with Abaco for Enhanced System Reliability
Abaco embraces the challenge of delivering enhanced system reliability and availability to the full gamut of embedded defense systems. Engage with our systems engineering experts to explore how the Health Toolkit can integrate with and deliver system health information to your real-time applications. We bring broad experience and a track record of success to embedded systems design. With Abaco, there is no push to adopt a special design style or implement using a proprietary interface; standard form factors and COTS components are our building blocks.

Conclusion

The Health Toolkit can increase reliability and availability for all types of systems, from ground-based radar and helicopter mission computers to smart torpedoes and UAVs. Until now, defense system embedded development has been left with a piecemeal approach to ensuring system reliability and availability. The Health Toolkit is the first commercial solution to take a holistic approach that covers all the hardware elements of the system and delivers integrated insight into their status, using a standard interface.

The Health Toolkit, with its data archiving capability and extensible, standards-based data model, is also laying the groundwork for future advances. Statistical analysis of large data sets, predictive analytics, and advances in AI will work together to see that system availability and reliability improve, despite increasing system complexity.