Knowledge-based Systems for Dynamic Maintenance

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The Purdue Knowledge Projection Group for NSWC Crane
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Effective maintenance procedures …

- Support maintainer throughout diagnosis and repair
- Increase operational availability and readiness
- Lower the total cost of ownership

That’s a good start, but ….
Revolutionizing Maintenance

A new concept for representation of maintenance procedures

- Guided step-by-step processing
- Action-based resource access
- Automatic web-based presentation
- Automatic session capture
- Session packaging for transmit
- Session analysis for knowledge discovery

A new philosophy for maintenance … pro-active not reactive

… a dynamic, knowledge-based system, supported by an infrastructure that allows us to learn continuously from the maintenance process itself.

Triggers … Failures … Actions … Observations … Parts…
Failure Patterns … Relationships … Root Causes …
Dynamic? Knowledge-based?

“\textquote“I need the removal procedures for this step”
\textquote“I need to compare my measurement to normal parameters”
(provides immediate access to action-based resources)
\textquote“I followed the procedure exactly, but the card was destroyed when I swapped” (identifies faulty procedures through session-based analysis and mining)
\textquote“I replaced this part just last week, but it failed again today” (determines root causes)

\textquote{“Describe in detail everything you tried so far for this fault – especially anything usual?” (serves collaborative maintenance)
\textquote{“This load CCA seems to fail consistently with this signal” (identifies engineering design problems)
\textquote{“What action sequences have been taken to resolve the many failures for this switch?” (links part replacement to diagnostic actions)“the longest yard”

Shipboard Sailor

Shore-side SME
Enabling technologies for capture, analysis and delivery of maintenance data

- XML representation of maintenance procedures to handle the enormity and complexity of any action and associated data
- Creation of XML content at earliest stages of manufacturing
- XSL transformations for automatic web-based presentation
- Action-based linkage to external & internal resources
- Automatic session capture
- Integration of non-traditional data types
- XML representation of captured session for web-based presentation
- Session packaging for ship-shore communication
- Session processing for dissemination of tacit knowledge, observations and experiences
Session-based knowledge discovery to support predictive and ultimately preventive maintenance

- Action statistics & resource tracking
- Action sequence analysis and streamlining
- Diagnostic history & failure-part analysis
- Action & session-based feedback
- Failure trigger & fault pattern analysis
- Intermittent/ shadow/ cascading fault tracking
- Text categorization framework for observation data
- Incorporation of sensor data

Knowledge Base

- Guided procedures, captured sessions, smartTables, smartImages, metadata for resource linkage
- Statistics, analysis & knowledge data
- Code, client communication, queue/transmission/synchronization
- Services offered to other Navy Projects
The Knowledge Projection System

Installed at NSWC Crane August 27, 2004 for shipboard troubleshooting simulation
The Knowledge Projection System

Shore-side KPS

• Ship-shore synchronization
• Session transmit & viewing
• SME recommendation processing
• Data mining
• Knowledge discovery
• Knowledge query
• Maintenance streamlining, maintenance training, equipment engineering, management reporting, ...

Shipboard KPS

• Online Troubleshooting
• Session capture
• Session transmit & viewing
• Ship-shore synchronization
• Session analysis feedback
• Knowledge query

XML Knowledge Base
Our Vision for Shipboard T/S

While running the ULM-4 range, port driver and port repeater BIT lights activated, at the same time ULM-4 range reported an immediate ...
... port forward high voltage distribution unit stuck relay ...
... unable to transmit from STBD antennae ...
... on the active side I noticed that when we are in AECM standby, power supply 3A3 for the port side has the high voltage light on, even though it isn't even on ...
... I get no readings on any of the TWTs as I toggle them ...
... I need to ask for advice on this problem since someone might have encountered it before and have an idea what is causing it. I think I have a bad TWT that might have caused the power supply and HVDU to go bad, but is it possible ...
... HV stuck relay causes constant high voltage to be applied to output TWT, trips HV power supply offline causing leveling fault ...

Troubleshooting Today

Our Vision for Tomorrow
We Deliver for the Sailors

Online Troubleshooting …

- Presents online interface to troubleshooting procedures
- Follows codified procedures step-by-step
- Handles any form of special procedures and incorporates them directly into the standard flow
- Automatically retrieves tech manuals, diagrams, tables at each step from clickable links
- Presents information links in order of usefulness and supports search of knowledge base
- Visualizes diagnostic flow path as dynamically constructed flowchart

Troubleshoot Online
We Capture Sessions

Troubleshooting action sequence for resolving a fault

Fault 6
Automatic Capture
Troubleshoot Scenario Subtest1
Operator ID EW1
Name Nick Covel
ShipID DECATOR DDG 73
ActionList

Action1
Subtest1 Event2 Look Up Fault
Comment HV stuck relay causes high voltage
TimeStamp Date 2003-10-09

Action2
Subtest1 Event8 Swap Interchangeable SRAs
Comment relay control card bad
TimeStamp Date 2003-10-09
Time 21:35:30

Action3
Subtest1 Event5 SDT Fault Report Change ?
Comment
TimeStamp Date 2003-10-09
Time 21:49:55
Answer YES
Elapsed Time 6.0

Login Information from the Portal

Look Up Fault

Swap 3A5A2 and 3A5A14

Run SDT and Check if Fault Reporting Changed

Looking at diagnostic toolsets to capture video, image, audio, device status, measurements and sensor data

Session Data is Small [xml text]
Tracks and analyzes action flow, system state, system changes, resources used, observations, ....

Mines recorded sessions to link valuable observations/experiences and actions

Mines recorded sessions to discover knowledge about action sequences, failure relationships, and patterns

Displays appropriate knowledge feedback to the sailor every step of the way

Enables SMEs and engineers investigate session knowledge, with the goal of predictive and preventive maintenance

Mining can be made real-time

Fault 39 troubleshooting procedure
Swap SRA step:
Swap relay cards 3A5A2, 3A5A3.

Warning:
when relay signal KAX/1 not at normal parameter, this swap action will destroy the A3 relay interface card

Link this warning to this swap event for this fault!

Triggers ... Failures ... Actions ... Parts... Relationships ... Patterns ... Root Causes ...
Knowledge Projection – Other Uses

“The Fleet” doesn’t have to be ships
- Cars, trucks
- Manufacturing equipment
- Any widely dispersed, long-life, capital intensive equipment with regular maintenance procedures!

Benefits
- Documentation cost savings
- Support for collaborative and remote troubleshooting
- Analysis of maintenance history across system lifecycle!

Do you see Knowledge Projection working for you? Let us know!
Knowledge Projection Team

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