Flexible Internet-based Diagnostics of Embedded Systems

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ESA 2004 – Las Vegas
24 June 2004

Motivation

- Trends in mass consumer products
  - Extended device functionality
  - Growing amount of software and electronics
  - Increasing system complexity
- Need for more diagnostic tests
- Need for trained specialists

- Consumer diagnostics today
  - Manually and electronically
  - On-site

- Disadvantages of on-site diagnostics
  - Costly travel times
  - Limited availability of specialists

Remote diagnostics of embedded systems
State of the art in remote diagnostics

Approach of flexible remote diagnostics

Realization Example

Summary

Outline

State of the art in remote diagnostics

Remote diagnostics via Internet

Efficient use of specialists
Reduction of costs
Non determined connection
No physical access

Existing solutions

<table>
<thead>
<tr>
<th>Module Type</th>
<th>Diagnostics</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device integrated</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Separate on-site modules Small modules (specific)</td>
<td>- -</td>
<td>+</td>
</tr>
<tr>
<td>Separate on-site modules Large modules (e.g. PC)</td>
<td>+ +</td>
<td>- -</td>
</tr>
</tbody>
</table>

On-site execution of timely and safety critical tests

Limited diagnostics or high costs
State of the art in remote diagnostics

Problem of differing boundary conditions

- Limited resources of embedded systems
- Number of on-site tests
- Increasing number of diagnostic tests
- Need of on-site execution of remote diagnostic tests

Today: permanent integration of diagnostic tests
- High amount of resources needed
- Inconvenient and limited modification possibilities

⇒ Solution: Flexible on-site adaptation for remote diagnostics

Meaning of diagnostic flexibility

Adapting system on demand
- Availability of needed specific diagnostic test
- Using new diagnostic tests unconsidered so far

⇒ No flexibility of today’s solutions

Outline

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- Realization Example
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Main aspects

- Prerequisite of remote access and electronically acquired signals
  - Integration of remote connectivity into the embedded controller
- Necessity of on-site execution of some diagnostic tests
  - Execution of remote diagnostic tests inside the embedded controller
- Consideration of limited resources
  - Distributed diagnostic system
  - Segmentation of diagnostic tests
- Realization of flexibility
  - Permanent static integration of all diagnostic tests as barrier for flexibility
  - Dynamic integration and remove of diagnostic tests on demand

System architecture

- Distributed diagnostic system
  - Device Under Test (DUT)
  - Remote diagnostic client
  - Diagnostic Server
- Classified distributed diagnostic tests
  - availability
    - permanently needed
    - temporarily needed
  - Execution location
    - on-site execution necessary
    - remote execution possible
Approach of flexible remote diagnostics

Structure of the embedded controller for those approaches

- Integration of diagnostics into embedded controller
  - Combined controller / diagnostic unit

- Core elements
  - Remote Connectivity
  - Flexible usable memory area
  - Diagnostic software environment
    - Control of download
    - Storage of diagnostic tests
    - Linking of diagnostic tests
    - Call and execution of diagnostic tests

Diagnosis sequence with flexible integration

1. Call of a diagnostic test
Approach of flexible remote diagnostics

Diagnostic sequence with flexible integration

1. Call of a diagnostic test
2. Download
3. On-site execution
Approach of flexible remote diagnostics

Diagnostic sequence with flexible integration

1. Call of a diagnostic test
2. Download
3. On-site execution
4. Return of raw data
5. Evaluation and preparation of diagnostic results
Approach of flexible remote diagnostics

Diagnostic sequence with flexible integration

1. Call of a diagnostic test
2. Download
3. On-site execution
4. Return of raw data
5. Evaluation and preparation of diagnostic results
6. Presentation
7. Erasing and deallocation
Outline

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Realization Example

Structure of the demonstration device

- Common washer-dryer
Structure of the demonstration device

- Common washer-dryer
- 23 Sensors/12 Actuators
- Combined electronic control/diagnostic unit
  - Internet Connection
  - Diagnostic environment
  - Remote connectivity and download possibility
- All units electronically connected
  - Direct access on sensors and actuators for diagnostic tests
Off-site diagnostic application

- Client-/Server-Application
  - Located on diagnostic server
  - Browser front-end for remote client

- Diagnostic features
  - Manual read-/write operations
  - Automatic test execution
    - Download transparent for technicians
  - Graphical representation of diagnostic results

- Enhancement possibility for new tests

Diagnostic possibilities of washer-dryer realization

- Initial State
  - No remote diagnosis possible

- Current State
  - Remote connectivity integrated and remote diagnosis possible
  - Amount of resources needed
    - Control Application (no diagnostic): 30 kB
    - Remote Diagnostic Environment: 24.2 kB
    - Internet Connection: 11.5 kB
    - Diagnostic Software Environment: 4.7 kB
    - Flexible Diagnostic Memory: 8 kB

- Comparison (average test size 0.5 kB)
  - Remote diagnostics (permanent) ⇒ 25 tests
  - Remote diagnostics (dynamic) ⇒ 85 tests + enhancement possibility

Number of errors currently identified
Outline

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Summary

- Limitations of diagnostic possibilities due to restricted resources
- Approach of flexible Internet-based Diagnostics of Embedded Systems
  - Distributed System
  - Flexibility by means of dynamic integration of diagnostic tests
- Advantages
  - Efficient use of resources due to distributed system
  - Increase of diagnostic possibilities
    - Handling growing number of diagnostic tests
    - Use of any combination of diagnostic tests
    - Use of diagnostic tests developed after delivery

Flexibility
Thank you very much for your attention!

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