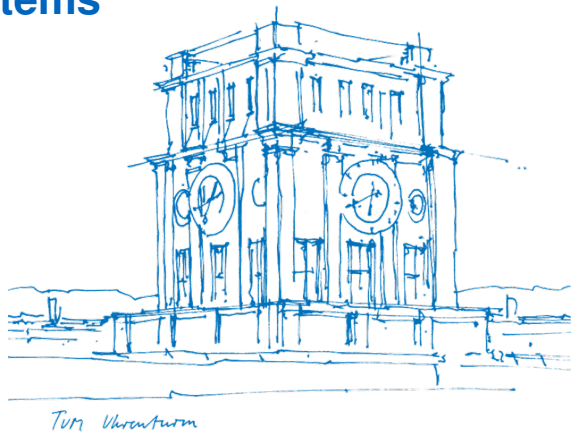
Chair of IT Security
Department of Informatics
Technical University of Munich

A Checkpoint Management System for Embedded Distributed Systems



Kevin Burton

Chair of IT Security
Department of Informatics
Technical University of Munich

December 1th, 2021

Outline

Motivation

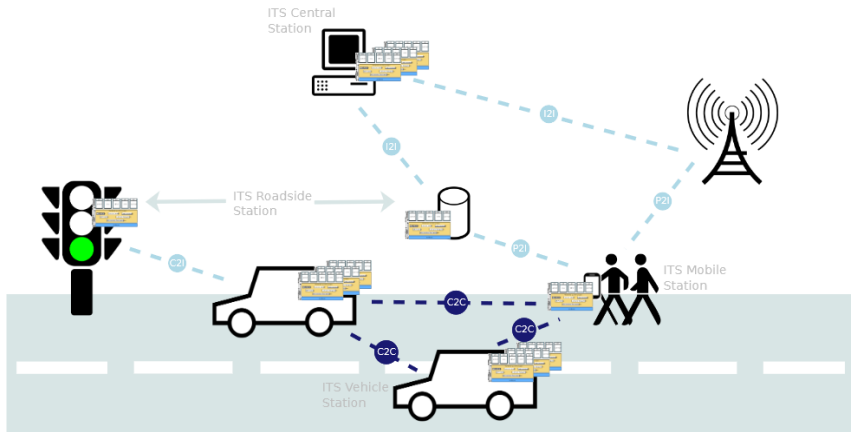


Figure 1 KIA4SM vision - homogeneous platform for heterogeneous devices [1]

Foundations

- Real-Time Checkpoint Restore (RTCR)

Foundations

- Real-Time Checkpoint Restore (RTCR)
- Distributed Shared Memory by Weidinger

Foundations

- RTCR
- Weidinger DSM
- Genode OS Framework

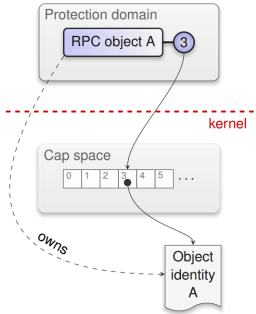


Figure 2 Relationship between an RPC object and its corresponding object identity [2, P.41]

Outline

Location of the CMS

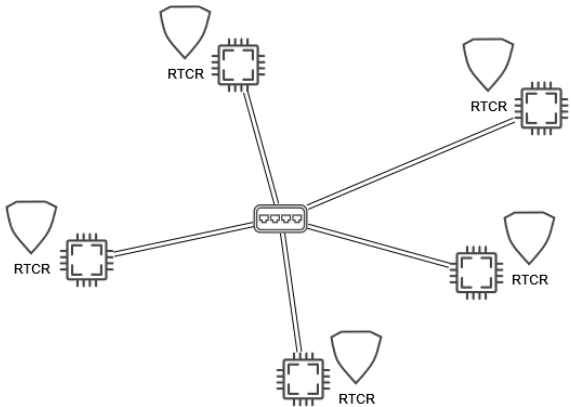


Figure 3 Network topology

Receiving and Storing of Checkpoints

- Publish/Subscribe

Receiving and Storing of Checkpoints

- Publish/Subscribe
- Weidinger DSM

Receiving and Storing of Checkpoints

- Publish/Subscribe
- Weidinger DSM
- Hybrid solution

Receiving and Storing of Checkpoints

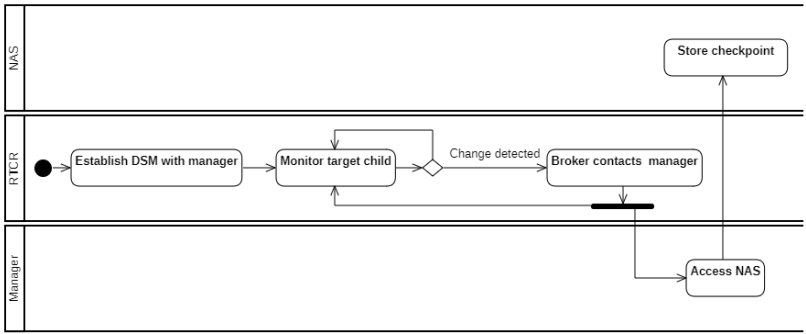


Figure 4 Activity diagram of checkpoint storing

Migration and Restoration

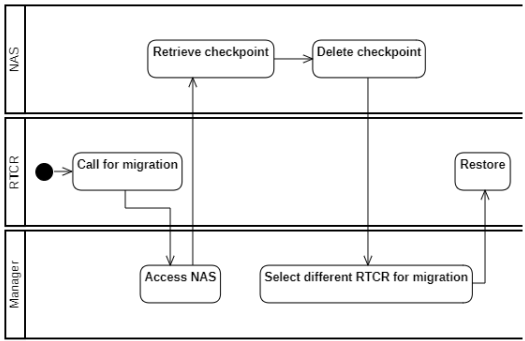


Figure 5 Activity diagram of migration and restoration

Outline

Simulating the Infrastructure

Dummy RTCR

- Establishes DSM
- Sends checkpoint
- Notifies of checkpoint
- Waits for 3 seconds, then calls for migration

Simulating the Infrastructure

DSM

Simulating the Infrastructure

NIC Router

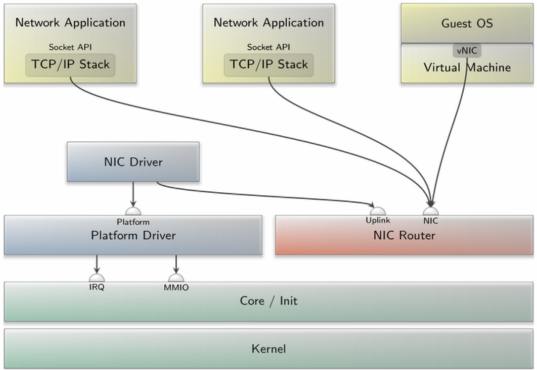


Figure 6 Genode network architecture [3]

Manager

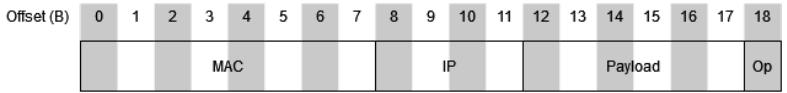


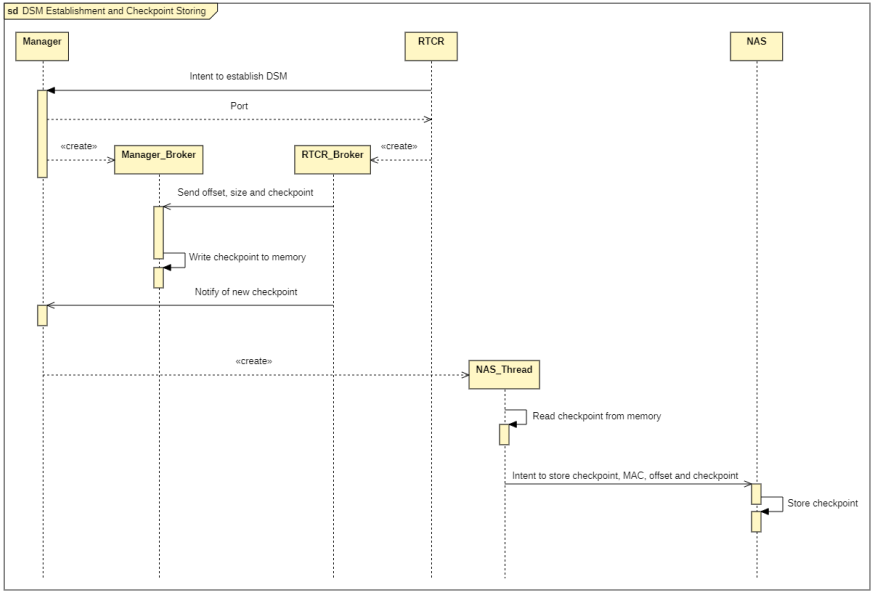
Figure 7 Message format expected on manager interface

- Opcode 0: DSM establishment
- Opcode 1: Notify of new checkpoint
- Opcode 2: Migrate and restore

NAS

Figure 8 Message format expected on NAS interface

- Opcode 0: Store checkpoint
- Opcode 1: Retrieve checkpoint


sd DSM Establishment and Checkpoint Storing
Manager
RTCR
NAS
Intent to establish DSM
Port
«create»
Manager_Broker
RTCR_Broker
«create»
Send offset, size and checkpoint
Write checkpoint to memory
Notify of new checkpoint
«create»
NAS_Thread
Read checkpoint from memory
Intent to store checkpoint, MAC, offset and checkpoint
Store checkpoint

Outline

Evaluation

Output of pseudo-DSM establishment

```
[init -> rtcr_dummy_2] Connecting to manager for DSM establishment
[init -> rtcr_dummy_1] Connecting to manager for DSM establishment
[init -> manager] [broker] Connection to broker successful.
   Establishing DSM on 1025
[init -> manager] [broker] Done updating memory
[init -> manager] [broker] Connection to broker successful.
   Establishing DSM on 1026
[init -> manager] [broker] Done updating memory
```

Evaluation

Output of checkpoint storing

```
[init -> rtcr_dummy_2] [broker] Notification of new CP sent
[init -> rtcr_dummy_1] [broker] Notification of new CP sent
[init -> manager] [NAS thread] Checkpoint successfully sent to NAS
[init -> nas] Checkpoint was stored successfully
[init -> nas] Checkpoint was stored successfully
[init -> manager] [NAS thread] Checkpoint successfully sent to NAS
```

Evaluation

Output of migration and restoration

```
[init -> rtcr_dummy_2] Calling for migration
[init -> rtcr_dummy_1] Calling for migration
[init -> nas] Checkpoint retrieved, sending to manager
[init -> nas] Checkpoint retrieved, sending to manager
[init -> rtcr_dummy_1] [Migr thread] Checkpoint dummy_2 received.
   Migration successful
[init -> rtcr_dummy_2] [Migr thread] Checkpoint dummy_1 received.
   Migration successful
```

Outline

Limitations and Future Work

1. Socket connection failure
2. Redundancy
3. Distributed shared memory
4. Dynamic IP and MAC determination
5. Physical test bench with real hardware NAS
6. RTCR integration
7. Real-time capability

Image Sources

1 Sebastian Eckl, Daniel Krefft, and Uwe Baumgarten. *KIA4SM - Cooperative Integration Architecture for Future Smart Mobility Solutions.* 2015.

2 N. Feske. *Genode Operating System Framework 21.05. Foundations [Online].* https://genode.org/documentation/genode-foundations-21-05.pdf. Accessed on 2021-10-22. 2021.

3 *Release notes for the Genode OS Framework 21.02. Pluggable network device drivers [Online].* https://genode.org/documentation/release-notes/21.02#Pluggable_network_device_drivers. Accessed on 2021-10-20.