Master's Thesis in Informatics

Port and Extension of a Toolchain Regarding Machine Learning Supported Schedulability Analysis in Distributed Embedded Real-Time Systems

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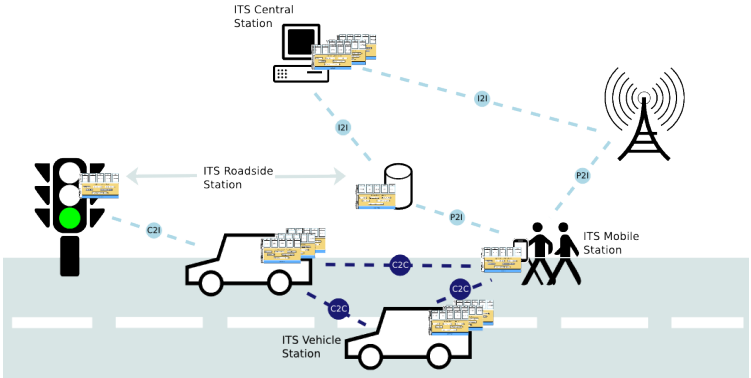
April 27, 2016

Outline

KIA4SM – Cooperative Integration Architecture for Future Smart Mobility Solutions

- Communication between ITS
- Organic computing
- MAPE paradigm



KIA4SM Requirements

Task loads are

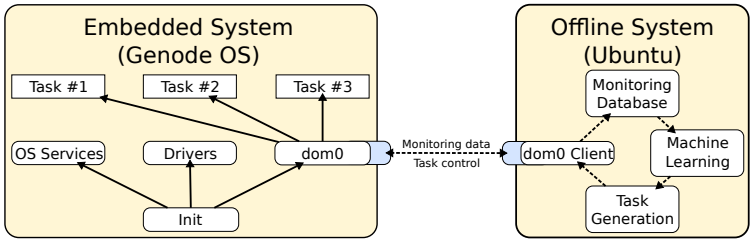
- random
- intermittent
- of varying priorities

Task Management

Tasks need to be

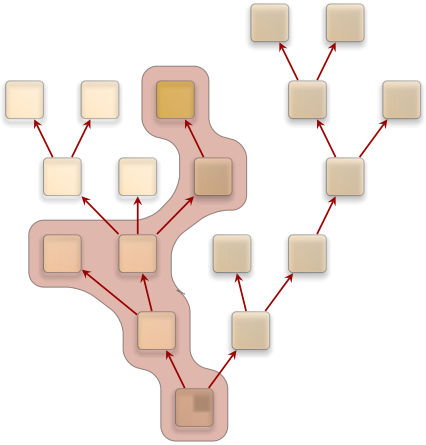
- scheduled
- migrated
- monitored

⇒ Machine learning



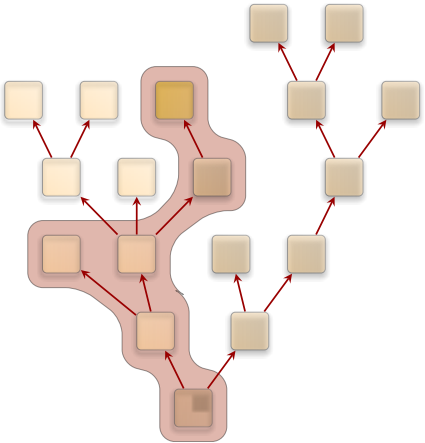
Genode Operating System Framework

- Microkernel and operating system
- Process protection domains
- Recursive component structure



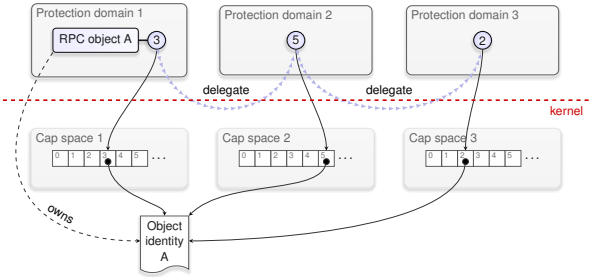
Genode Promises

- Secure
- Safe
- Minimalistic
- Scalable



Genode Structure

- Delegation of capabilities
- Services use capabilities
- Resources wrapped by services

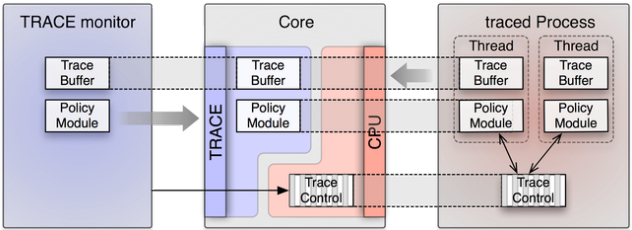


Component Creation

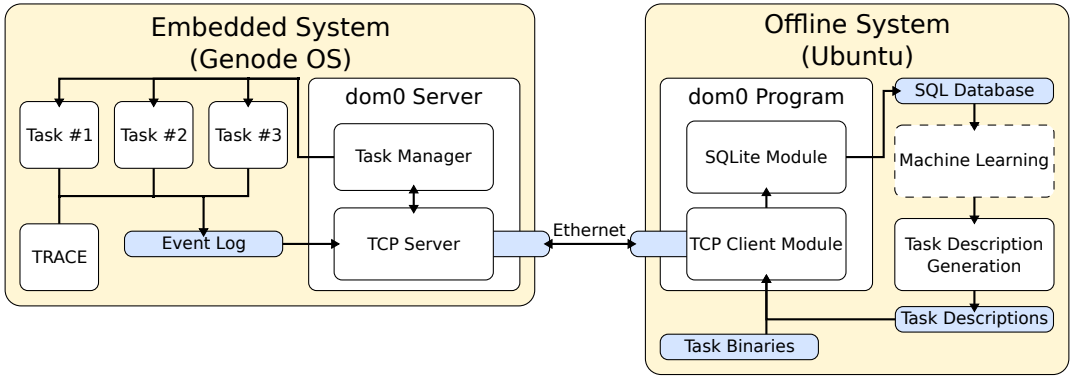
- ROM session
- RAM session
- CPU session
- RM session
- PD session

TRACE Service

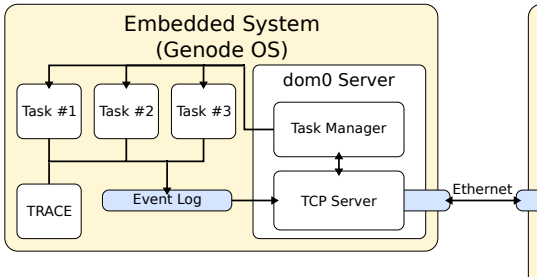
- Runtime information on components
- Optional trace buffer
- Optional policies
- Execution time



The dom0 Toolchain

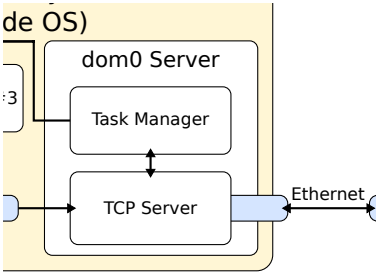


The dom0 Toolchain



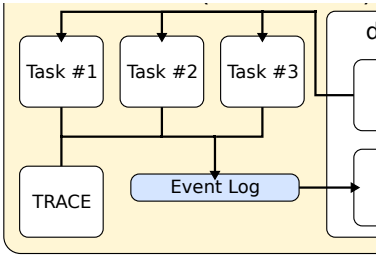
- Genode system
- Limited resources
- Microkernel and minimalistic OS
- Monitoring and execution (**M**AP**E**)

The dom0 Toolchain



- Autonomous task management
- TCP/IP communication
- Control and monitoring

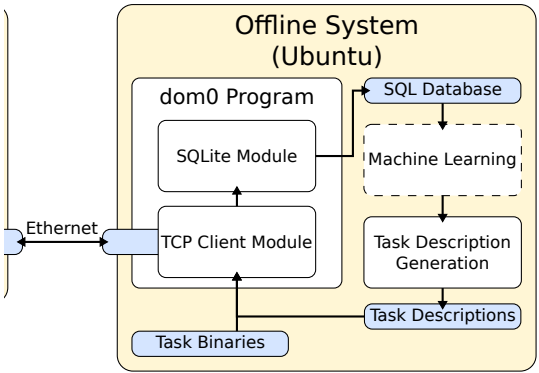
The dom0 Toolchain



- Child allocation and destruction
- TRACE information
- Asynchronous event logging

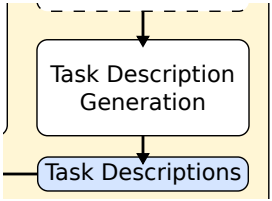
The dom0 Toolchain

- Linux system
- Virtually unlimited resources
- Arbitrary applications
- Data analysis and planning (M**AP**E)



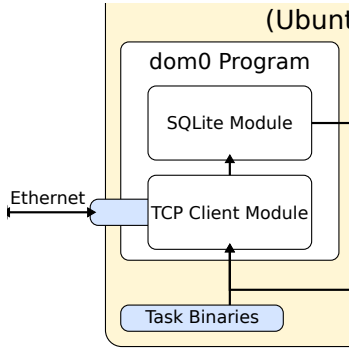
The dom0 Toolchain

- Task descriptions generated by tms-sim
- Binary, period, deadline, priority
- Runtime arguments
- Mostly random



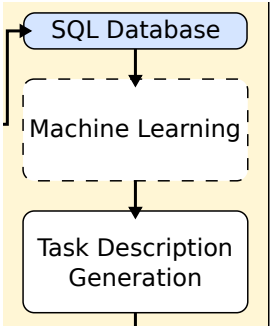
The dom0 Toolchain

- Python
- Programmable sequence of commands
- Forwards binaries and descriptions
- TCP/IP client
- SQL converter

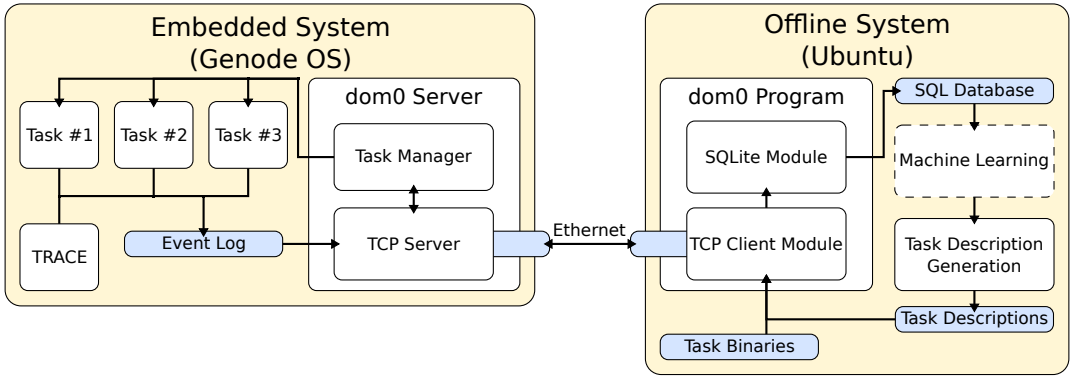


The dom0 Toolchain

- Event log as SQLite database
- Future machine learning system
- Final link in feedback loop



The dom0 Toolchain



Performance Metrics

- Execution time (TRACE service)
- RAM usage (RAM service)
- Deadline misses (custom implementation)
- CPU idle time (always-busy, low-priority task)

Implementation

- dom0 server in C++ on Genode
- dom0 client in Python
- Task description generation in C++ using tms-sim

Results

Descriptions

```
<periodictask>
  <id>1</id>
  <executiontime>0</executiontime>
  <criticaltime>0</criticaltime>
  <ucfirmr/>
  <uwmean>
    <size>10</size>
  </uwmean>
  <priority>57344</priority>
  <period>0</period>
  <offset>0</offset>
  <quota>80%</quota>
  <pkg>idle</pkg>
  <config>
    <arg1>120568</arg1>
  </config>
</periodictask>

<periodictask>
  <id>2</id>
  <executiontime>859</executiontime>
  <criticaltime>859</criticaltime>
  <ucfirmr/>
  <uwmean>
    <size>10</size>
  </uwmean>
  <priority>32768</priority>
  <period>3470</period>
  <offset>0</offset>
  <quota>80%</quota>
  <pkg>tumstmul</pkg>
  <config>
    <arg1>134492</arg1>
  </config>
</periodictask>
```

Event log

```
<profile>
  <task-descriptions>
    <task-id="0"-execution-time="0"-critical-time="0"-priority="0"-period="0"-offset="0"-
    quota="4052172B"-binary="task-manager"/>
    <task-id="1"-execution-time="0"-critical-time="0"-priority="57344"-period="0"-offset="0"
    -quota="8388608"-binary="idle"/>
    <task-id="2"-execution-time="859"-critical-time="859"-priority="32768"-period="3470"-
    offset="0"-quota="8388608"-binary="tumstmul"/>
    <task-id="3"-execution-time="3207"-critical-time="3207"-priority="8192"-period="3740"-
    offset="0"-quota="524288"-binary="namaste"/>
  </task-descriptions>
  <events>
    <event-type="START"-task-id="1"-time-stamp="38158">
      <task-id="36"-session="init"-> task-manager"-thread="01.idle"-state="UNTRACED"-managed
      ="no"-execution-time="70"/>
      <task-id="35"-session="init"-> task-manager"-thread="02.tumstmul"-state="UNTRACED"-
      managed="no"-execution-time="73"/>
      <task-id="34"-session="init"-> task-manager"-thread="03.namaste"-state="UNTRACED"-
      managed="no"-execution-time="58"/>
      <task-id="33"-session="init"-> task-manager"-> 01.idle"-thread="01.idle"-state="
      UNTRACED"-managed="yes"-execution-time="0">
        <managed-task-id="1"-quota="8388608"-used="167936"-iteration="1"/>
      </task>
      <task-id="32"-session="init"-> task-manager"-> 03.namaste"-thread="03.namaste"-state="
      DEAD"-managed="no"-execution-time="0"/>
```

SQL table

	task_id	event_id	execution_tir	quota	used	iteration
1	1	0	0	8388608	167936	1
2	0	0	263949	31907840	5271552	0
3	2	1	0	8388608	167936	1
4	1	1	0	8388608	167936	1
5	0	1	274204	23347200	5275648	0
6	3	2	0	524288	167936	1
7	2	2	0	8388608	167936	1
8	1	2	0	8388608	167936	1
9	0	2	284387	22650880	5279744	0
10	3	3	23865	380928	356352	1
11	2	3	0	8388608	167936	1
12	1	3	0	8388608	167936	1
13	0	3	285588	22654976	5279744	0
14	2	4	386031	8224768	3543040	1
15	1	4	0	8388608	167936	1
16	0	4	290457	23355392	5275648	0
17	2	5	0	8388608	167936	2

Results

- Task manager can handle arbitrary task sets
- Periodic tasks with deadlines
- Event log features monitoring data at the most important program points
- SQL conversion allows structured and programmatic analysis of data

Questions?

Showcase

Future Work

- Task migration
- Machine learning integration
- Managed dataspaces