OSGi Community Event 2010

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Experiences with OSGi in industrial applications

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- Requirements, Implementation and Experiences
  - Runtime platform for computation algorithms (HA)
  - Middleware for machine control
  - Vehicle sensor data gateway / simulator
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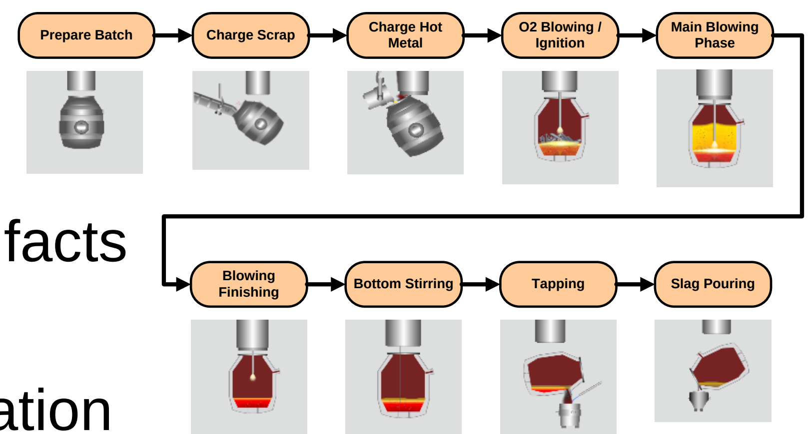
Who we are

- Institution for applied sciences
  - outsourced R&D
  - deliver and prepare product ideas
  - Partner for innovative projects with new technologies
- Founded July 1999 by departments of the Johannes Kepler University Linz
- Integral part of the Softwarepark Hagenberg
- Form of Organisation: Non-Profit Ltd
- ~50 staff members
- Partially founded by the Austrian Government

Competence Centers for Excellent Technologies

Computation Runtime: Context

- Domain Steelmaking
- Complex computational process models (PM)
- PM guiding and controlling various tasks during phases of steelmaking process
- PM date back to the 70s → Typical problems of ageing software
- PMs scattered over IT infrastructure
- Various types of deployment artifacts
- Inconsistent interfaces
- Inaccurate or lacking documentation



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Computation Runtime: Requirements

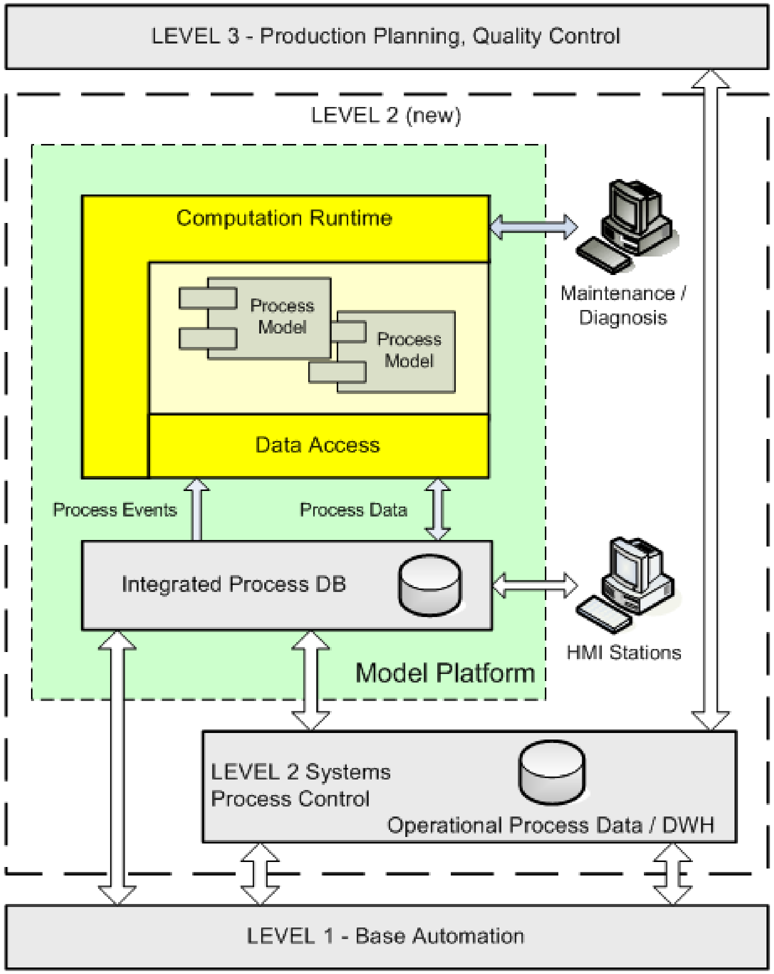
- Overall project goals
  - Reducing efforts for PM maintenance and testing
  - Shortening PM rollout times
  - Reducing troubleshooting times

- Functional Requirements
  - Pluggable PM components
  - Versioning support
  - Unified data access
  - Legacy code integration
  - Rule based & parallel execution
  - Integration with modern IDE

- NF Requirements
  - High availability (24x7)
  - Fault tolerant
  - Portability (Win, OpenVMS)
  - Preferably based OSS
  - Simplicity for PM maintainers (metallurgists)

Computation Runtime: Implementation

- Located at Level 2 (ISA-95)
- CR acts as container for PM, manages PM instances and their metadata
- executes computations based on simple rules
- Generic data access framework: passive or active data acquisition
- Uses third party process DB



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Computation Runtime: Implementation / Experiences

- Implementation based on Eclipse Equinox
  - from V3.2 on sufficiently stable
  - Some issues with OpenVMS → changes in OSGi core and runtime
  - Some infrastructure bundles (CM) from Knopflerfish
- Pluggable PM modules with versions: out of the box
- Legacy code support: there, but doesn't solve JNI stability issues
- Parallel execution with help of Eclipse runtime jobs
- Execution rules: compiled Boolean expressions

Computation Runtime: Stability & HA

- Framework itself proved very stable
- PM bundles might be unstable
  - Unstable native code crashes whole CR
  - ➢ launch PMs containing native code in own process
  - ➢ Automatic version fallback: “last known good PM version”
  - Computations (or callbacks) may block
  - ➢ CR and PM communication must be interruptible any time
- PM bundles might be greedy / evil
  - ➢ Restricting PM code via OSGI Permission Management
  - Works for e.g. thread or socket operations
  - Not for excessive memory usage/turnover and CR’s SPI usage

Computation Runtime: Stability & HA

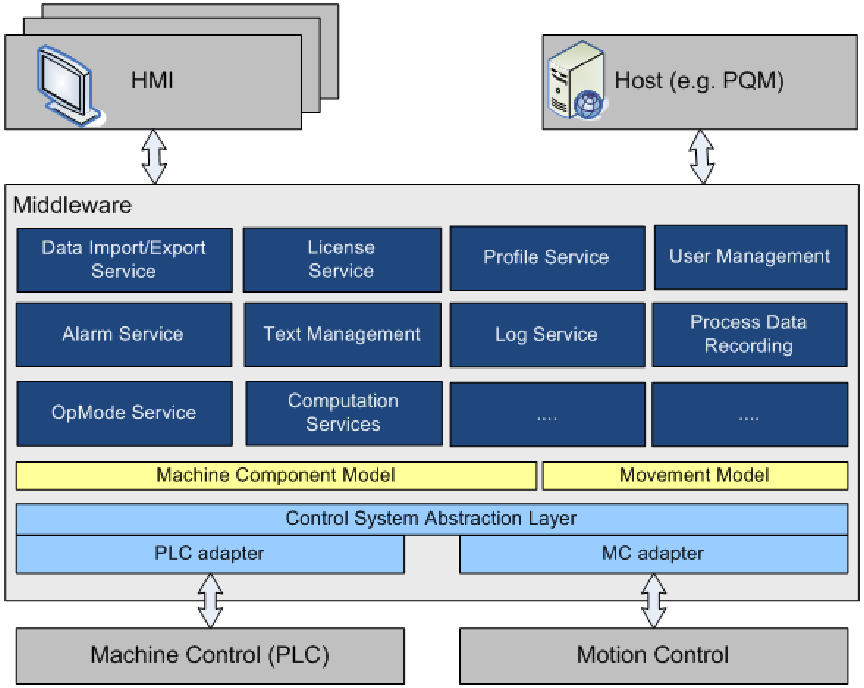
- More measures to achieve High Availability:
  - Full standby system – may be switched within seconds
  - Isolation of experimental PMs in their own runtime.
  - Delayed PM bundle updates: only in certain process phases
  - Blocking PM configuration (via OSGi CM) on operative PMs
- Recovery
  - OSGi framework state
  - additional state information saved via OSGi preferences service

Machine Control MW: Context / Req.

- Domain machine automation
- Middleware for decoupling HMI & other clients from PLCs
- Must support product lines
  - Large number of different (but related) machines
  - Vast variety of feature options for each machine
  - Different vendors of PLCs
- Restricted HW resources (CPU, RAM)
- Dynamic updates of SW during machine operation
- Broad range of functions: read and influence machine state, variables, operations

Machine Control MW: Implementation

- CS adapters as set of bundles
- Machine and Movement model based on Eclipse EMF
- Services realized as set of bundles
- Varying functionality as full bundles or as fragments
- Binding between modules via declarative services



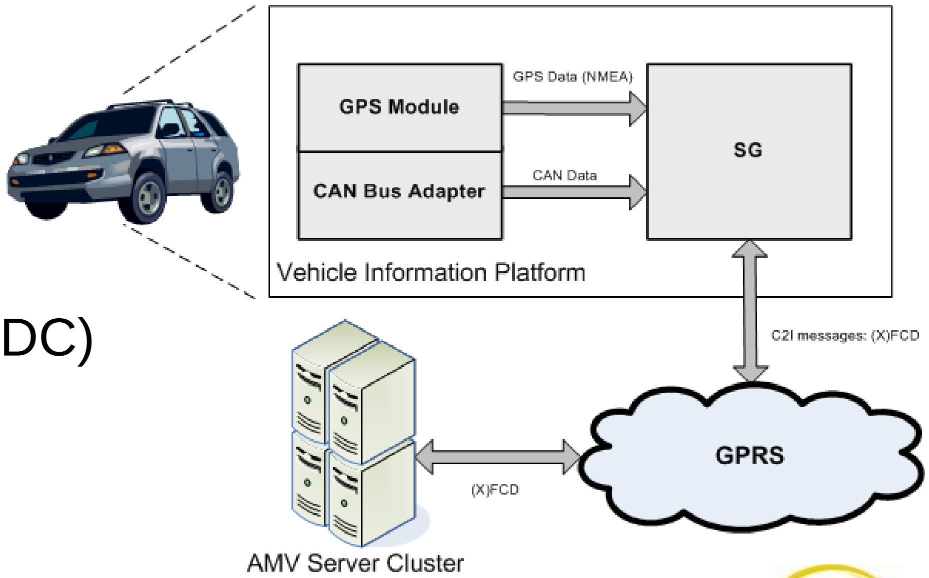
- HMI integrated into MW - directly using OSGi services
  – Coupling remote HMIs via ECF/remote OSGi
  – Other clients (host) coupled via WebServices (Jetty as httpd)

Machine Control MW: Experiences

- Declarative services: Easy to use, dependencies more comprehensible
- ECF/remote OSGi
  - Alternatives examined: dOSGi, RMI based proprietary solution
  - ECF because of support in Eclipse + performance
  - Runs well, only some minor issues: e.g. rOSGi Provider silently fails upon CNFE
  - ECF/rOSGi – EMF: (Eclipse Issue 245014): problems with serializing of EMF objects: workaround via manual externalization
- Machine Data Sync initially with Eclipse CDO
  - Promising functionality, but too much heap dynamics
  - too low performance on target system
  - dependencies bloated code base

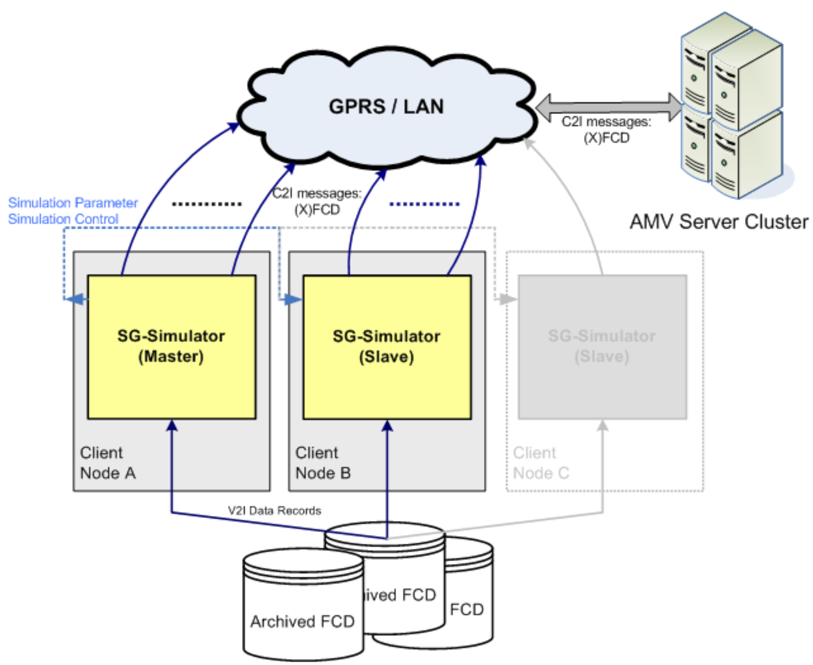
Sensor Data Gateway (SG)

- SW gateway for collection, preprocessing and transmission of vehicle data
- Deployed into car - part of infotainment system
  - Easy update of components during operation
  - Remote diagnosis
  - Configurable data filters
  - Event detection (e.g. emergencies)
  - Limited resources (Java CDC)
  - “self healing” capabilities



SG Simulator

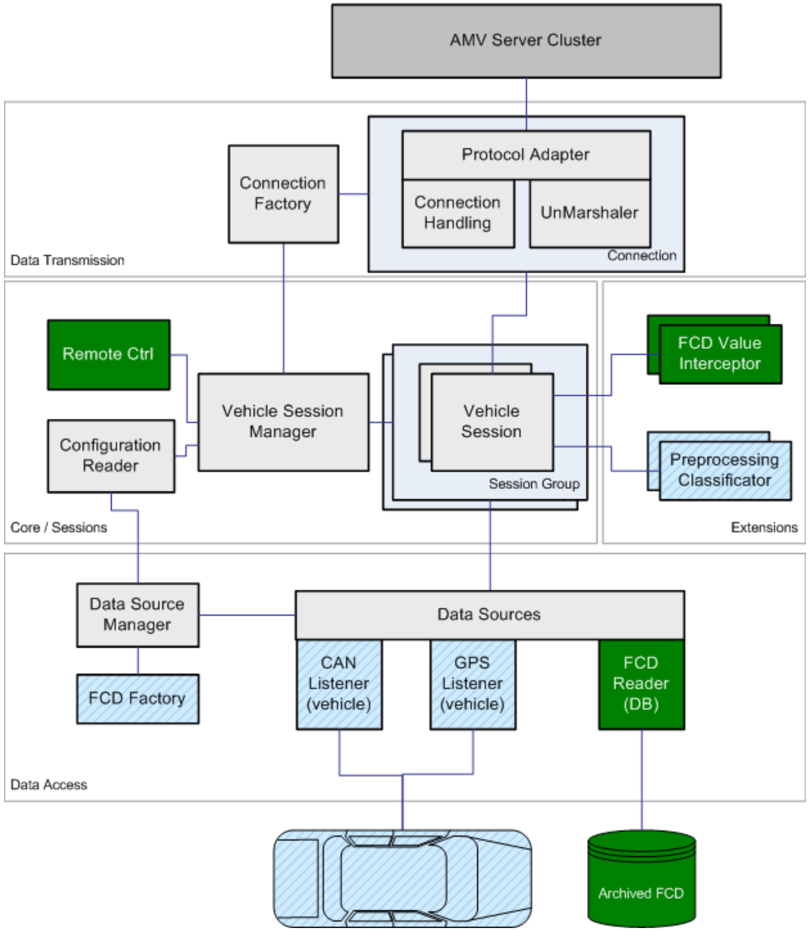
- Distributed simulation of vast amount of vehicles
- Flexible amount of simulator slave nodes
- Playback of prerecorded vehicle data



- Flexible data variance per vehicle session
- Multiple data sources per simulation scenario possible
- Reuses most of SG code base

SG: Architecture / Implementation

- Layered architecture
- Core bundles are common to SG and simulator
- Special functionality for SG and Simulator in optional bundles
  - SG: CAN + GPS Listener, FCDFactory
  - Sim: Remote Control (M/S), FCDReader
- Dynamic extensions
  - SG: Preprocessing Classificators
  - Sim: Value interceptors → Data variance



SG: Experiences

- Straightforward application customization
  - Different applications with shared core
  - Module structure eases maintenance
- SW updates on running vehicle out of the box
- Sim M/S communication:
  - First prototype used proprietary protocol (DRPC)
  - switching to ECF/remoteServices in the future
- OSGi Execution environments proved helpful
  - SG: Java Mobile CDC
  - Simulator: Java 6

More lessons learnt

- Following best practices pays off
- Granularity of bundles: Encapsulate code in own bundle if
  - can be reused in other context
  - has to be maintained independently
- Separation of API interfaces and implementation bundles:
  - Increases # bundles
  - decouples dependent bundles: allows easy change of implementation
- Bundle dependencies may become very complex
  - Increases with package level dependencies (and version matching)
  - Impossible to handle without tool support

More lessons learnt

- Dynamic nature of OSGi must be taken care of
  - Can't rely on permanent bundle/service availability
  - Possible awkward behavior upon bundle update: e.g. Dependency graph rerouting restarts bundles.
  - Classloading may raise confusing issues esp. combined w. reflection
- Declarative Services help reducing complexity
  - DS for optional or lazily needed services
  - exposed and needed services obvious at development time
- Testing
  - Testing can easily be automated
  - Full test bundles for (partial) integration testing → Continuous Integration
  - Bundle fragments for non public package testing

Conclusion

- We use OSGi mainly for headless, server-like applications
- OSGi applicable for industrial applications
  - Sufficient stability (of implementation of choice)
  - Offers everything for dynamic modifications
  - Rather small footprint
  - Runs in reduced environments
- Some constraints though
  - Not for time critical (Hard RT) applications
  - Cannot eliminate Java's stability risks