Common meta model for workflows in Manufacturing and SOA

Willie Lötz
The South African Breweries Ltd

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The South African Breweries Limited

A subsidiary of SABMiller plc

Introduction: SABMiller

SAB
The South African Breweries Limited

A subsidiary of SABMiller plc

- The South African Breweries Limited was founded in 1895
- The company became SABMiller plc in 2002 when it purchased the Miller Brewing Company in the US
- SABMiller is listed in London and Johannesburg
- SABMiller is the world's largest brewer by volume, following growth in China, the acquisition of Grolsch and the merger of Miller and Coors in the US in 2008
- SAB Ltd is the South African operation of SABMiller plc and currently produces approximately 26-million hectolitres of beer per annum and sells 16-million hl of other beverages through its soft drinks division, ABI.

Scope of our operations today

SAB
The South African Breweries Limited
A subsidiary of SABMiller plc

- Over 200 owned brands
- Brewing interests and distribution agreements spread across 6 continents and in over 60 countries
- Brewed over 240 million hectolitres of lager in the year ending 31 March 2008
- Over 47 million hectolitres of non-lager beverages sold in the year ending 31 March 2008
- Six of our brands are in the world's top 50 beer brands.
- We are also one of the largest bottlers of Coca-Cola products in the world.

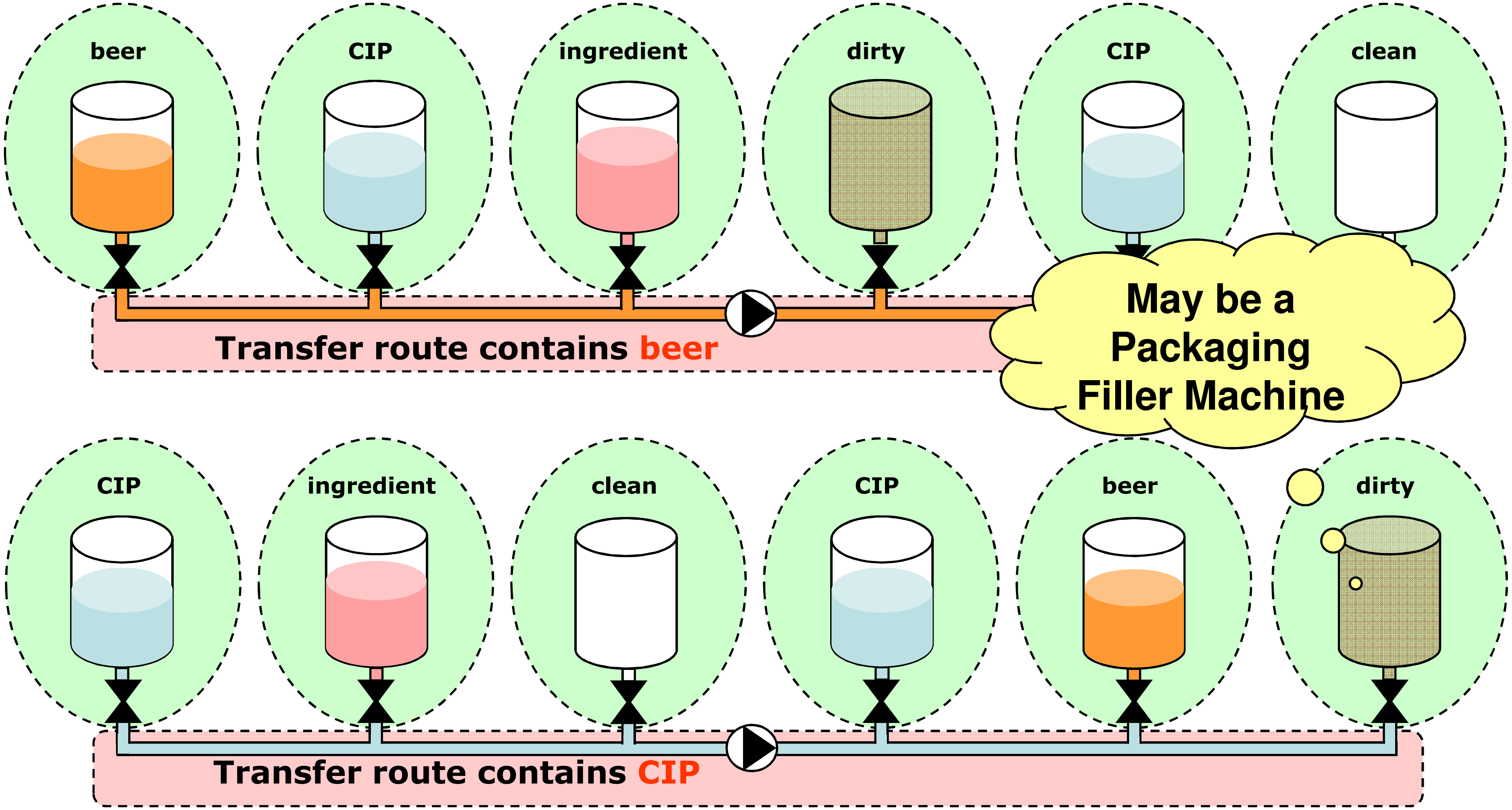
Some Goals

- Enforce good corporate governance of all manufacturing processes
- Corporate performance benchmarking at a global level
- Strategic investments in technology to support business imperatives
- Sustainable technology platform
- Agility to meet future demands
- Reduced total cost of ownership

Business imperatives:
Local brewery perspective

- Assured robustness of equipment safety interlocks and regulatory compliance.
- Prevent material cross-contamination and ensure product integrity.
- Explicitly enforce process interlocks.
- Validated manufacturing procedures at all plants at all times.
- Apply single governance framework for manufacturing in hybrid plants.
- Support product and process tracing, production analyses and performance benchmarking in a consistent framework.
- Improve plant performance with process context through real-time visibility, quality, customer responsiveness, and regulatory compliance.
- Define common patterns and develop reusable components to guide effective systems design and deliver efficient operation.
- Optimise dynamic production scheduling and execution per site.

Typical Manufacturing Process Problem



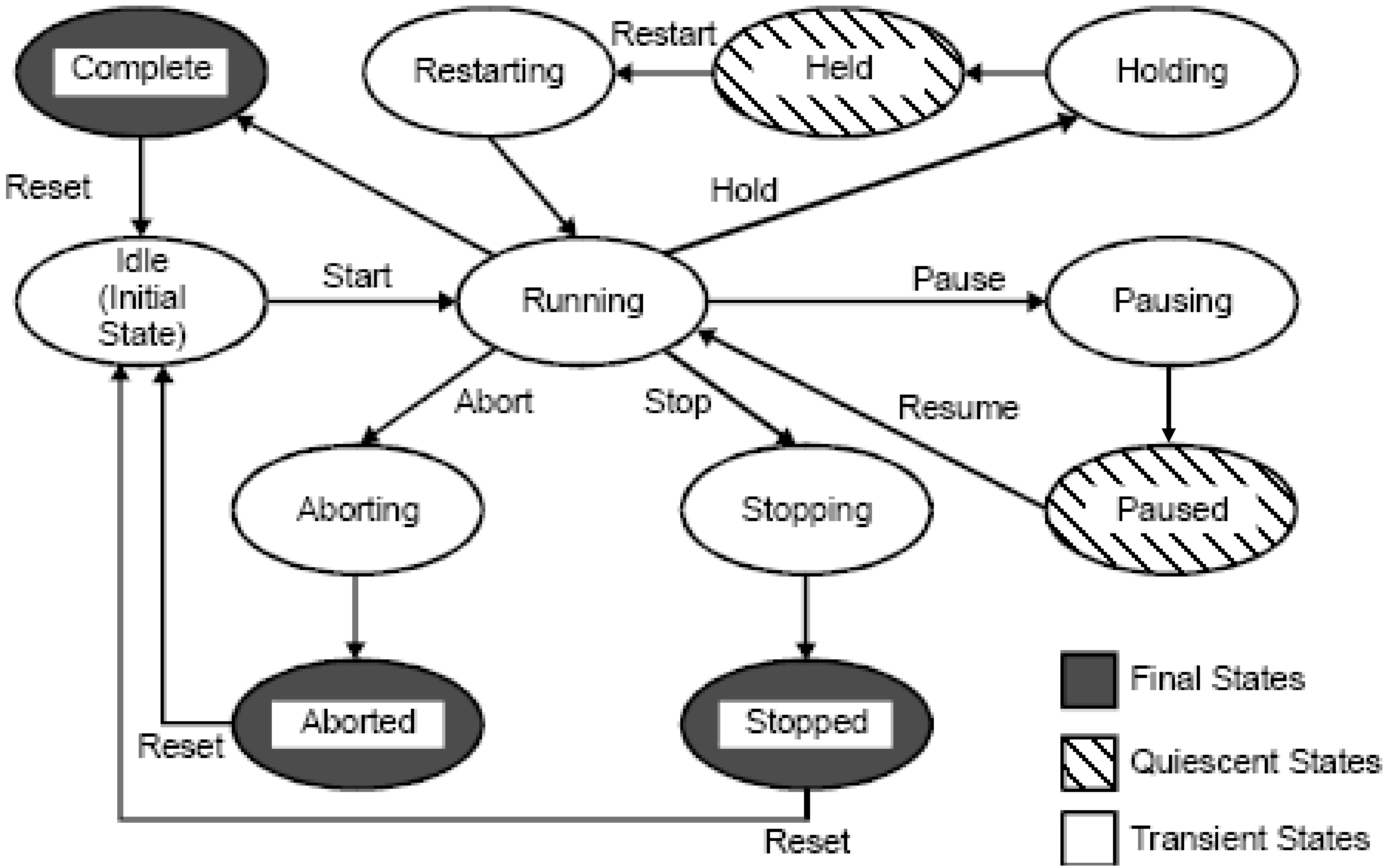
Standard Equipment State Models don't provide information to indicate the influence of material on the vessels and routes.

Can Recipes prevent all disasters?

- **Recipes only define the *expected* actions – they can't prevent the unexpected exception events.**
- **Recipes have no control when equipment is manipulated *manually*.**
- **To *ensure* process interlocks, equipment safety and material integrity, each equipment entity must locally control the permissible process actions of all the Control Modules embedded in it at all times.**
- **A Finite State Machine embedded in the Equipment Basic Control can *enforce* the correct use of equipment and process integrity under all circumstances irrespective of the external Mode of control or exception events.**

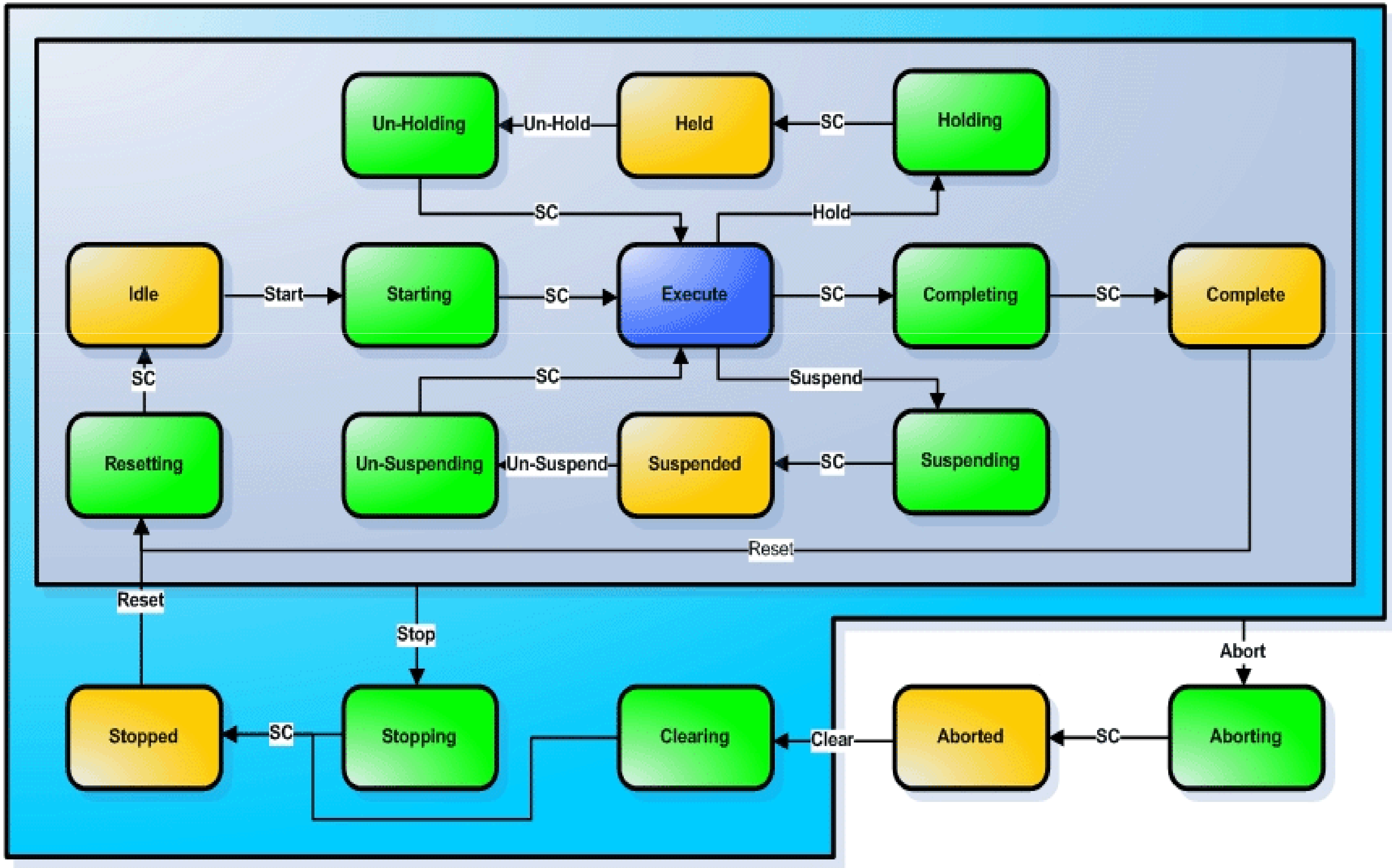
Equipment Workflow Model - 1988

ISA S88.01: Equipment State Transition Model

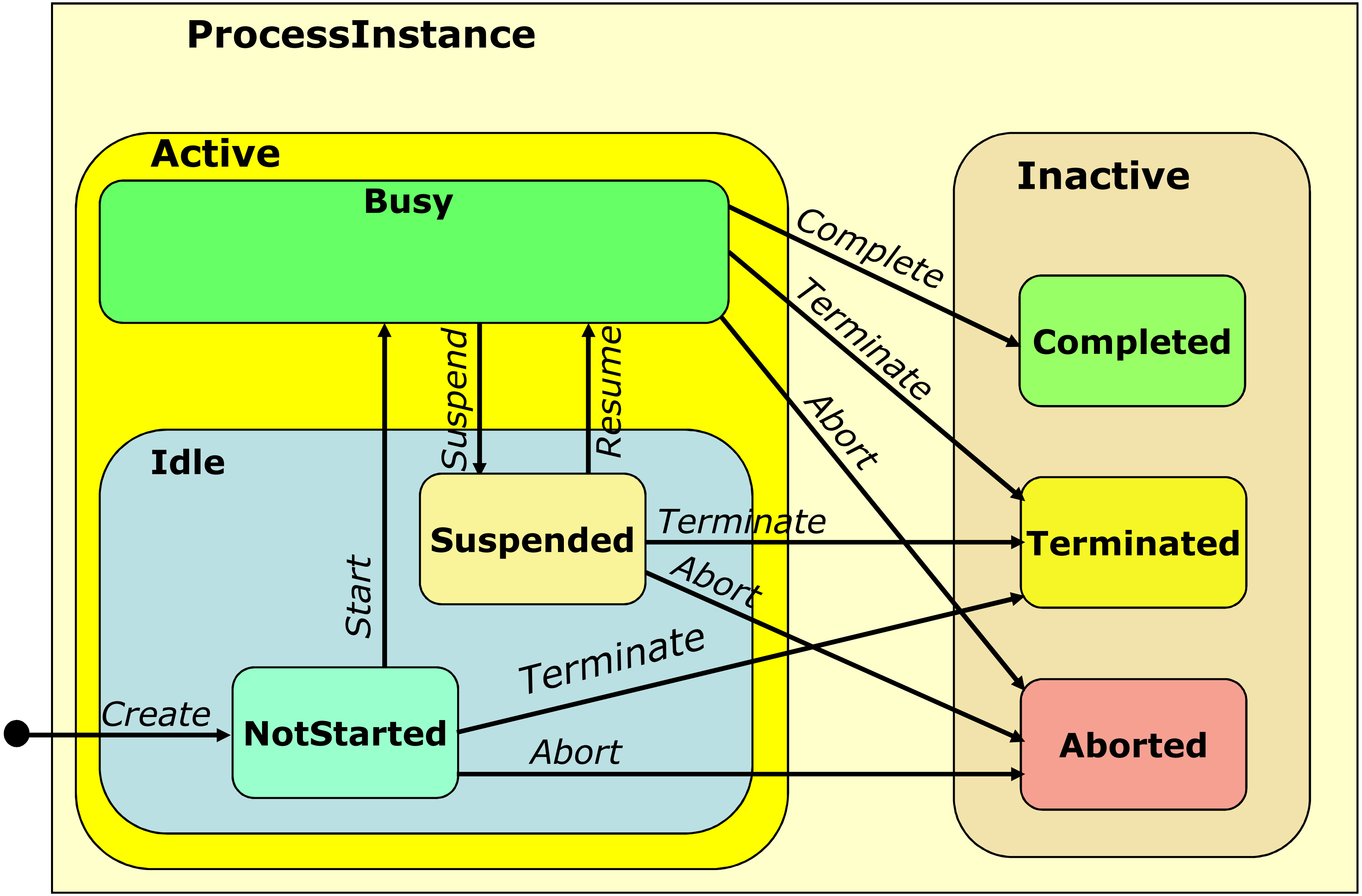


Equipment Workflow Model - 2006

PackML v3.0: Machine State Model

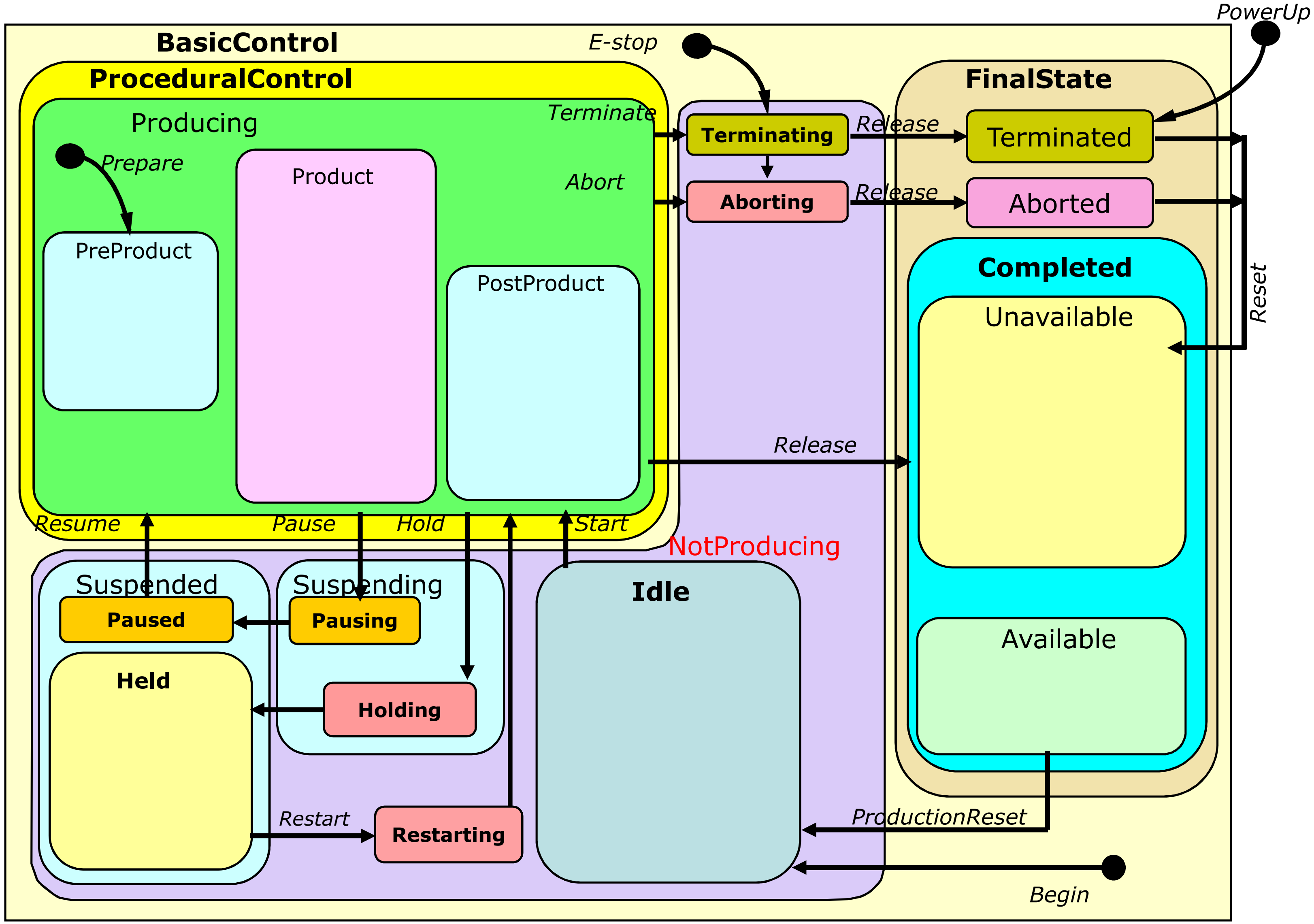


Generic Workflow Model - Statechart



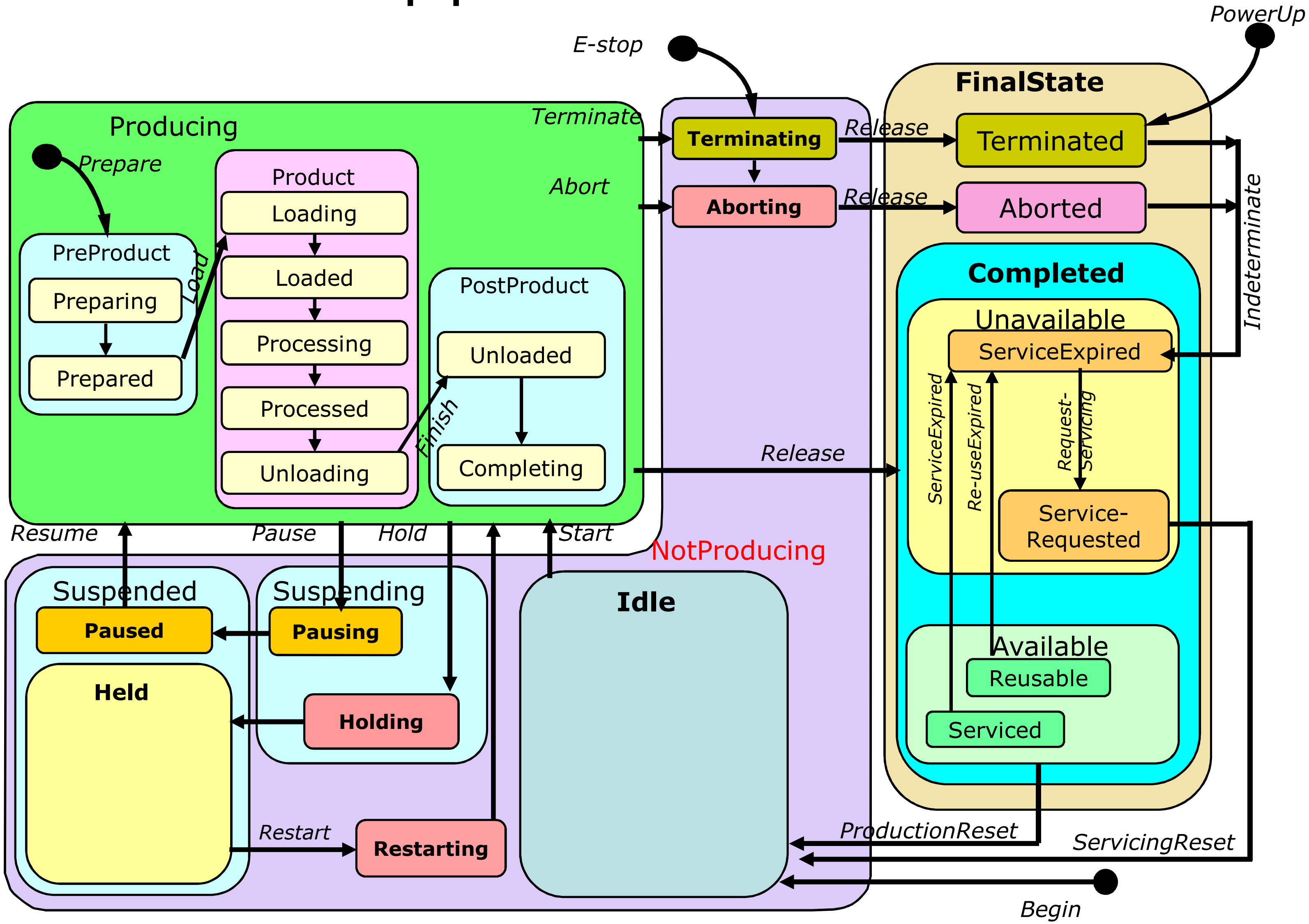
Equipment model as State Chart

Generic Equipment Statechart

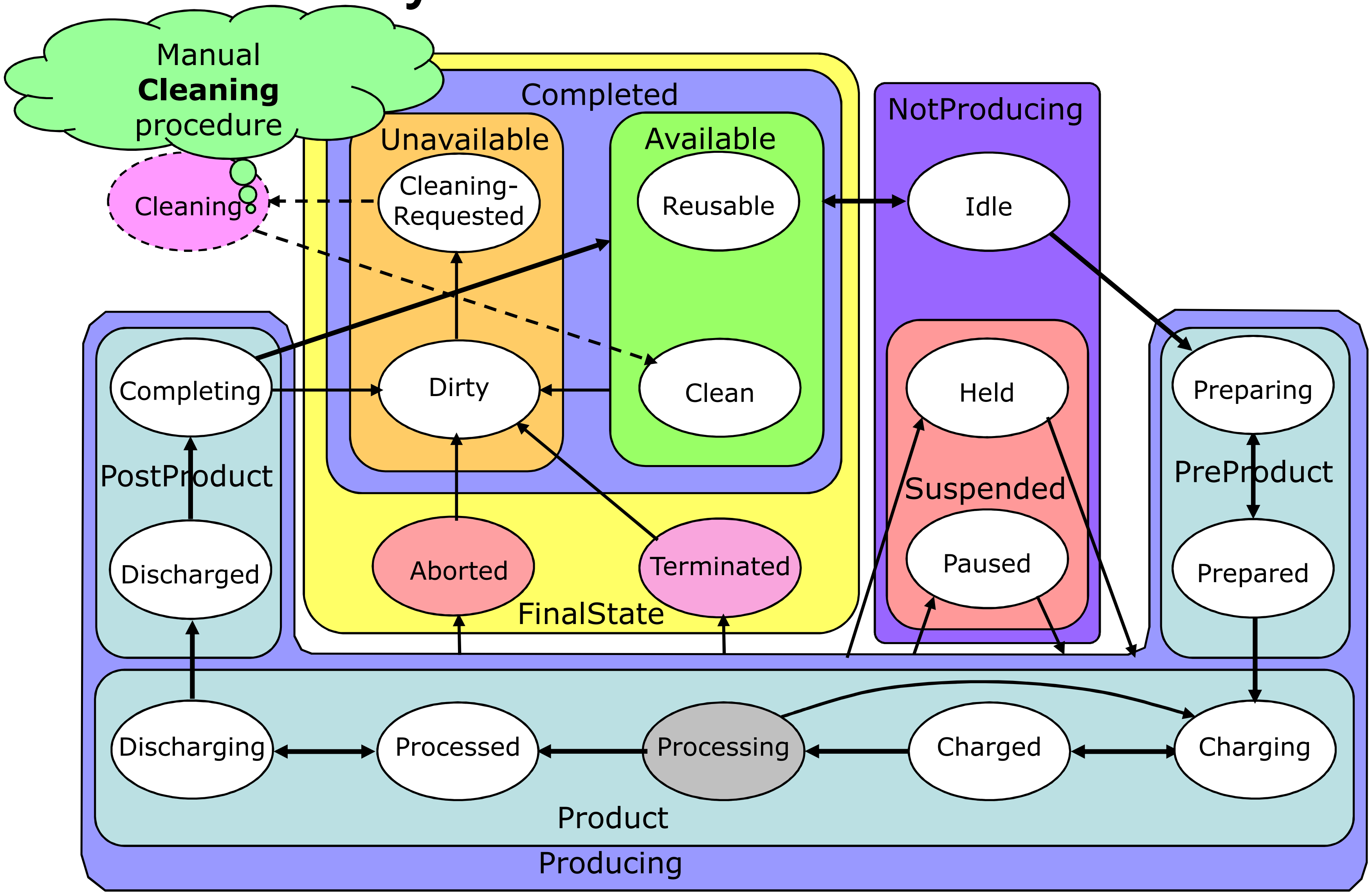


Manufacturing Workflow Model - extended

Generic Equipment Process Statechart



Visualisation of Generic Equipment Process Cycle - Batch Process Context



Lessons learned, local perspective

SAB: 7 breweries

- Manufacturing Control and Execution System layers are well supported via existing Commercial Of The Shelve software (Microsoft .NET Framework).
- A uniformly applied Equipment Process State Model can dramatically enhance manufacturing business benefits of SOA.
- Maturity of existing vendors to leverage potential interoperability of Web Services to relate and integrate information is sadly lagging.
- Corporate governance of implementations becomes increasingly difficult for multiple distributed sites intending to apply standardised models - even when only one local company and one country with 7 breweries are involved.
- A multitude of heterogeneous existing system implementations using different process models, naming conventions, object relationships, business rules and semantic interpretations require massive human intervention for each “roll-out” project after the initial pilot.

Equipment Process State Models are existing in SAB
– the rest of this presentation reflects only my own view.

Global corporate perspective

SABMiller: 200 brands, 6 continents, 60 countries

- Technical interconnectivity to many geographically distributed areas using different IT infrastructure and application languages is not a problem.
- Interpretation of the large mass of existing information requires huge human effort and time.
- The “standard” B2MML example of XML Schema for ISA 95 still suffers from the extensive human effort to understand, interpret and map data at each site to the ISA 95 descriptions.
- B2MML is still essentially a single point solution with different incoherent interpretations and inconsistent local extensions.
- Corporate integration of multiple heterogeneous sites, different languages, cultures and process models need standardised information structures to ensure consistent machine interpretation of the information content of messages.
- Semantic models with manufacturing domain ontologies should alleviate some of the pain to arrive at knowledge integration and extract business benefit through machine reasoning.

Future corporate business models

- **Horizontal knowledge integration:**
  - improve standardization of detailed manufacturing value stream within MES.
  - *standardise Service interface semantics*
- **Vertical knowledge integration: MES to ERP**
  - use business model and concepts of ISA-95.01
  - *standardise Service interface semantics*
- **Integrated Advanced Planning & Scheduling**
  - dynamic updates of real-time Manufacturing grid status
  - *standardise Service interface semantics*
- **Improve end-to-end SCM integration**
  - Supply grid, Manufacturing grid, Distribution grid
  - *standardise Service interface semantics*

Unambiguous interpretation via Ontology based SOA

Semantic Interoperability

- To move from simply presenting information to where computer programmes can exchange it, combine it with other information resources and subsequently process it in a meaningful manner.

Semantic Interoperability Centre Europe
http://www.semic.eu/

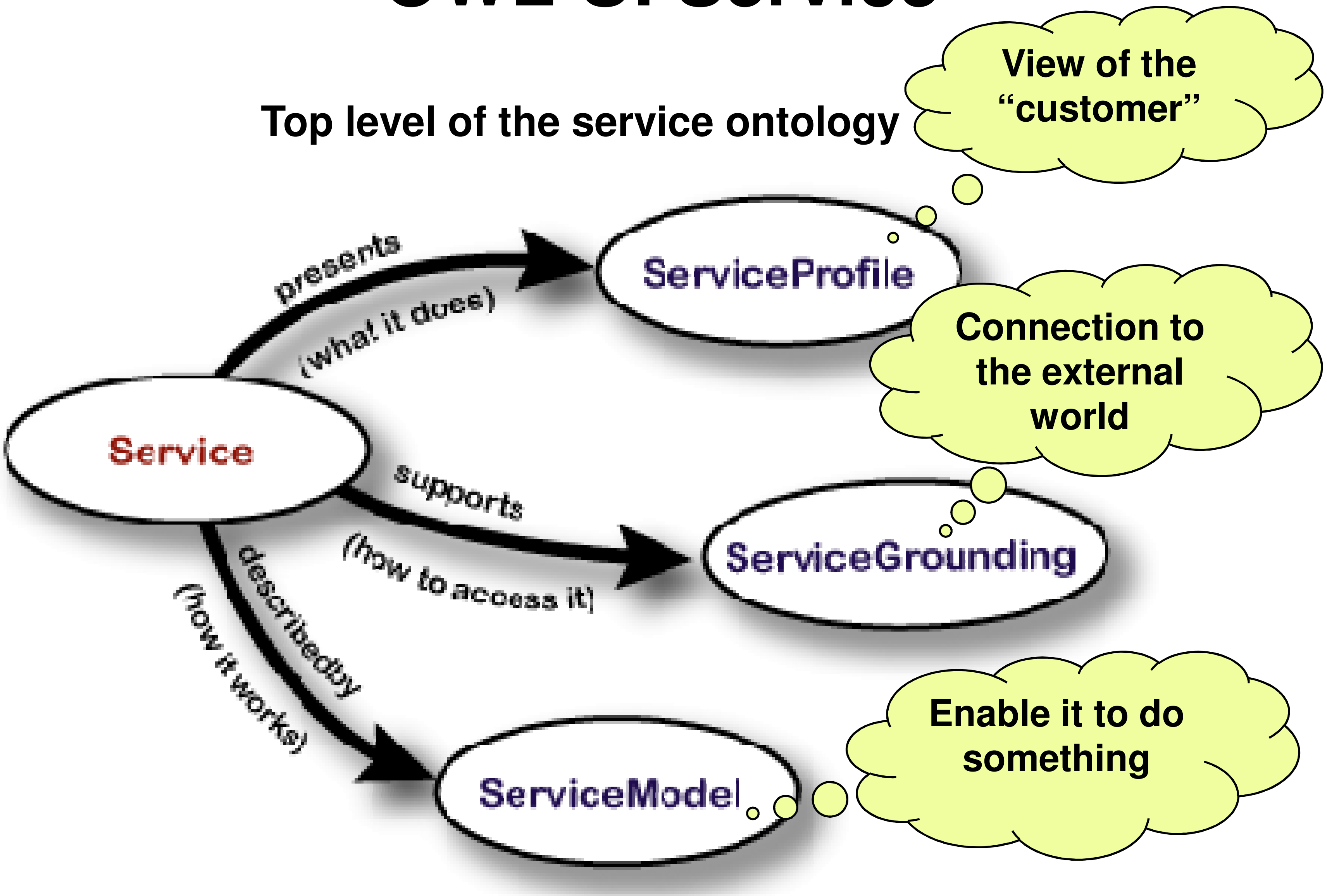
Promising SOA enhancement

Ontology Web Language - OWL

- OWL Web Ontology Language is designed for use by applications that need to process the content of information instead of just presenting information to humans.
- OWL Full inherits the semantics from RDFS and is a full first order logic language.
- OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema (RDFS) by providing additional vocabulary along with a formal semantics.
- OWL-S provides Web Services implementation by using standard features of WSDL.
- A super set of Control Constructs enables modelling of OWL-S composite services in terms of workflows.
- OWL-S defines the ontology for Inputs, Outputs, Preconditions and Results (IOPR).
- Logical conditions may be expressed by pure OWL statements or more expressive semantic languages (SWRL, KIF, DRS).

http://www.w3.org/TR/owl-features/ http://www.ai.sri.com/daml/services/owl-s/1.2

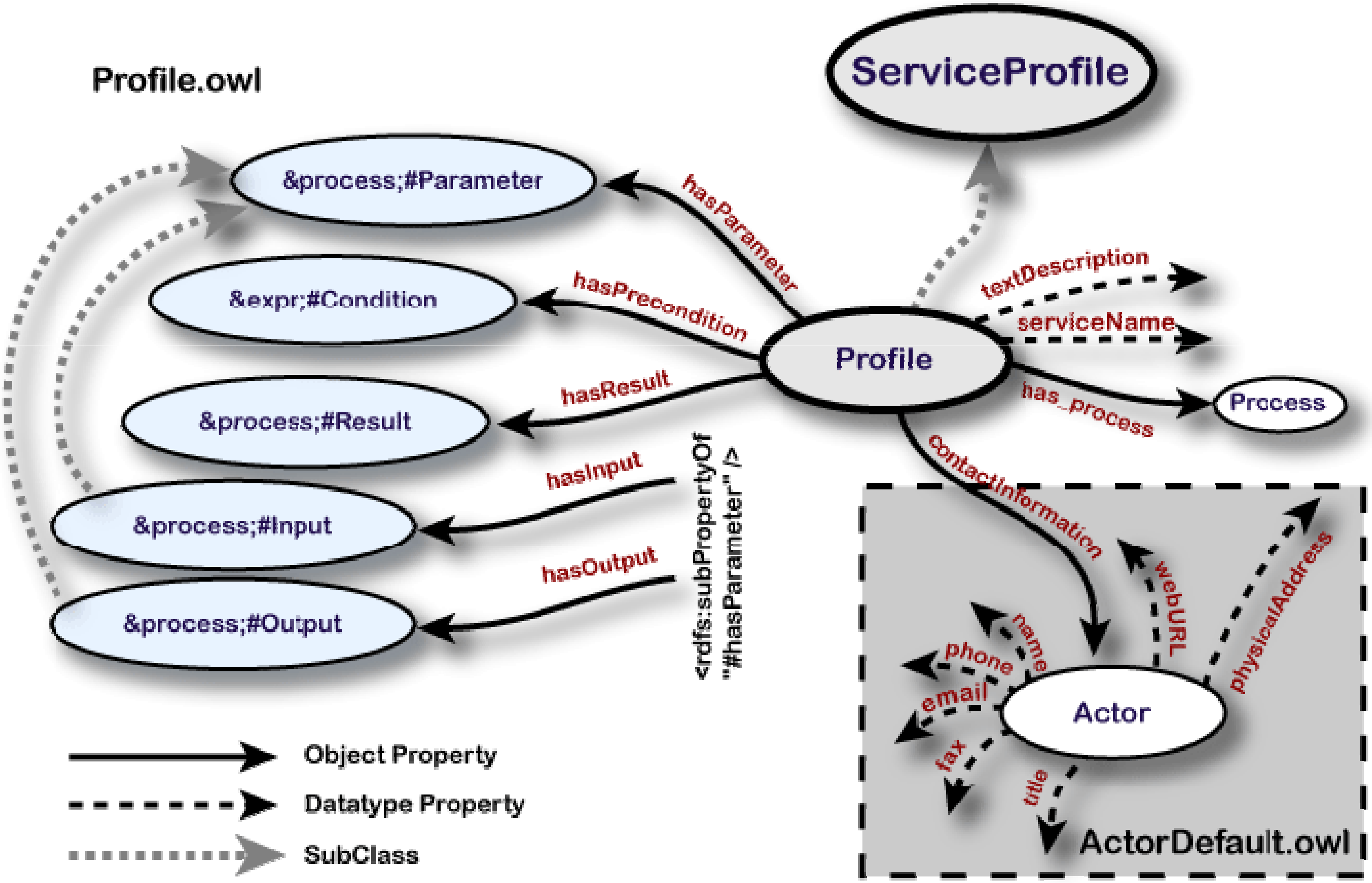
OWL-S: Service



http://www.ai.sri.com/daml/services/owl-s/1.2

OWL-S: ServiceProfile

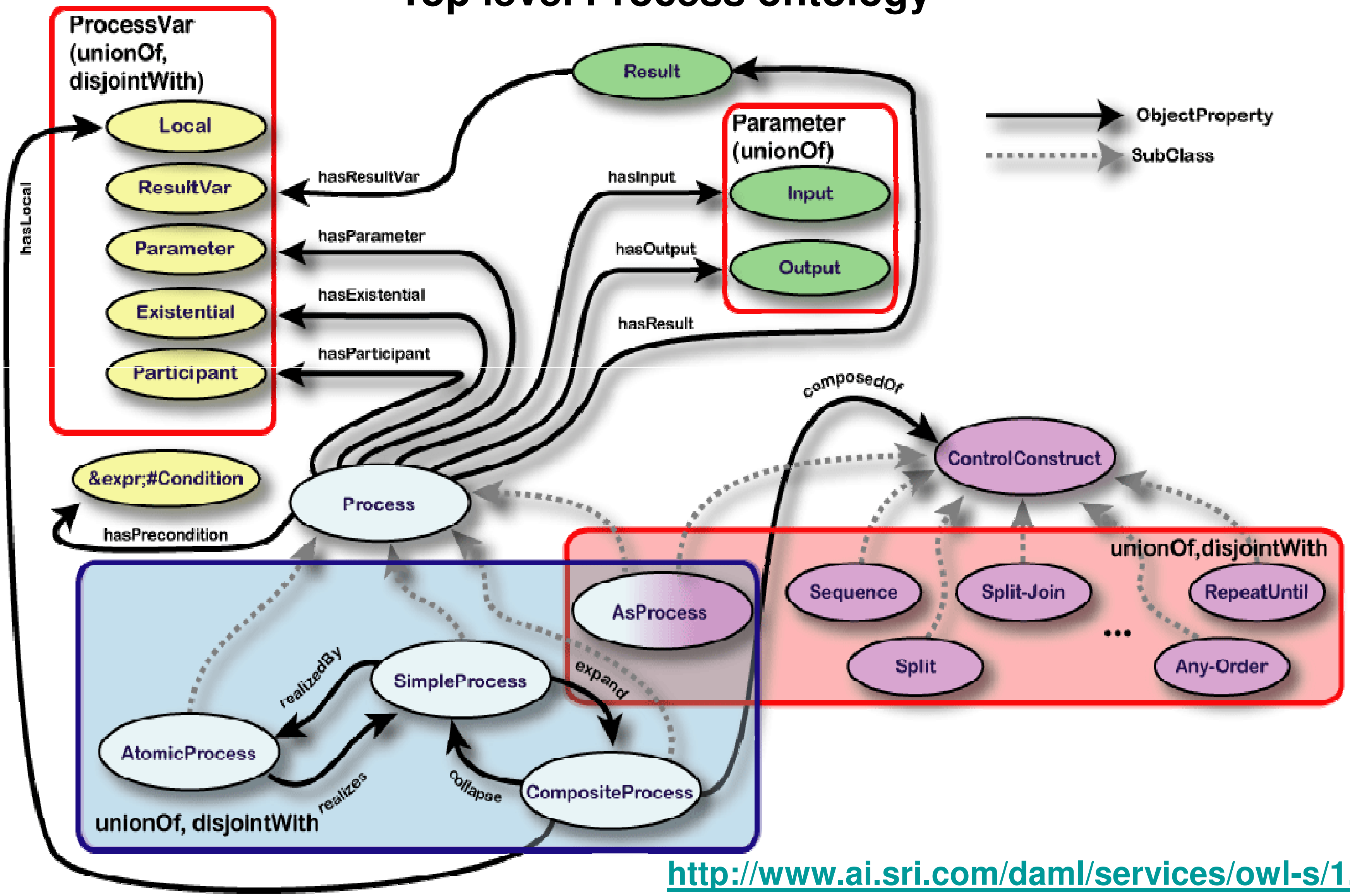
Selected classes and properties



http://www.ai.sri.com/daml/services/owl-s/1.2

OWL-S: ServiceModel

Top level Process ontology

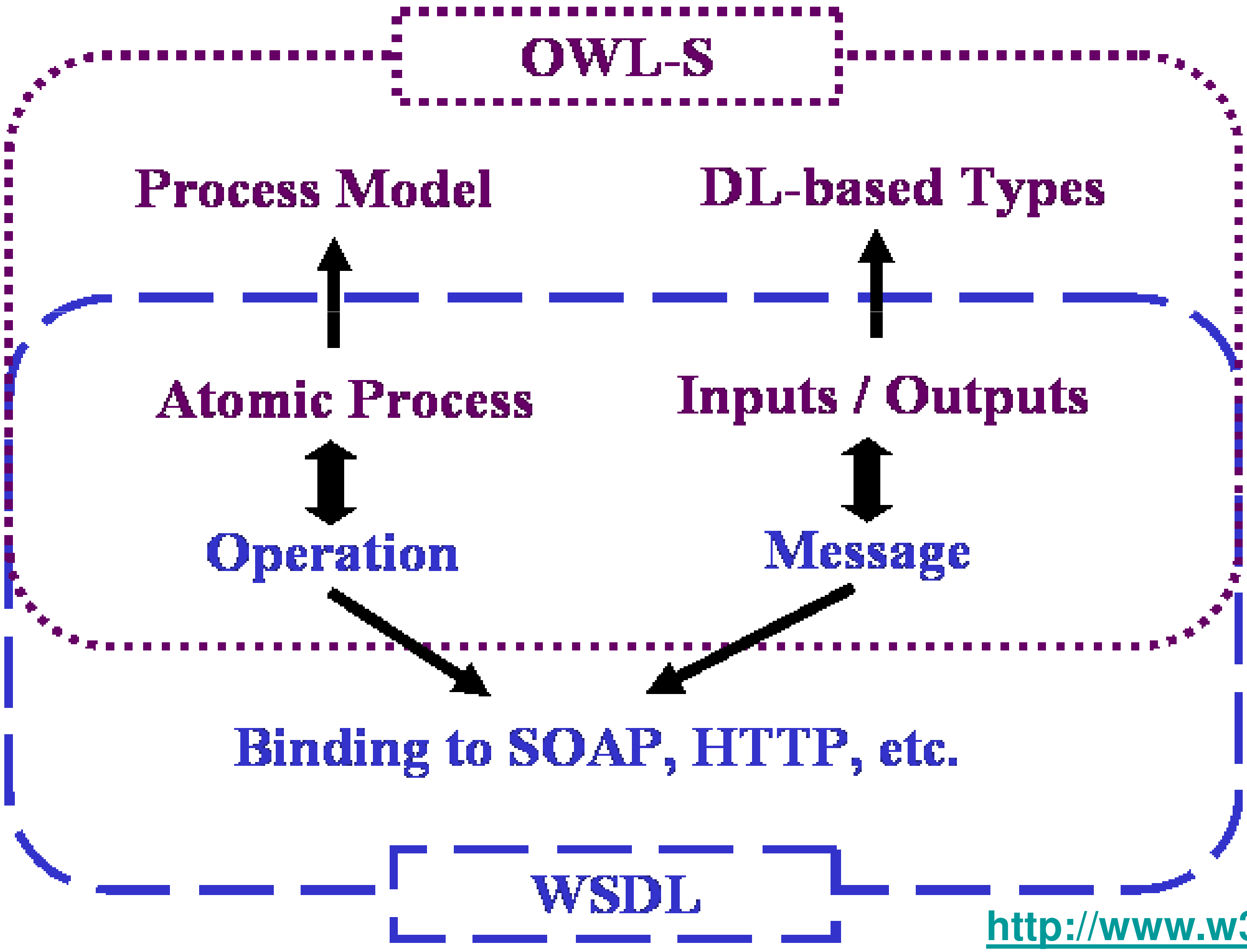


http://www.ai.sri.com/daml/services/owl-s/1.2

OWL-S: ServiceGrounding

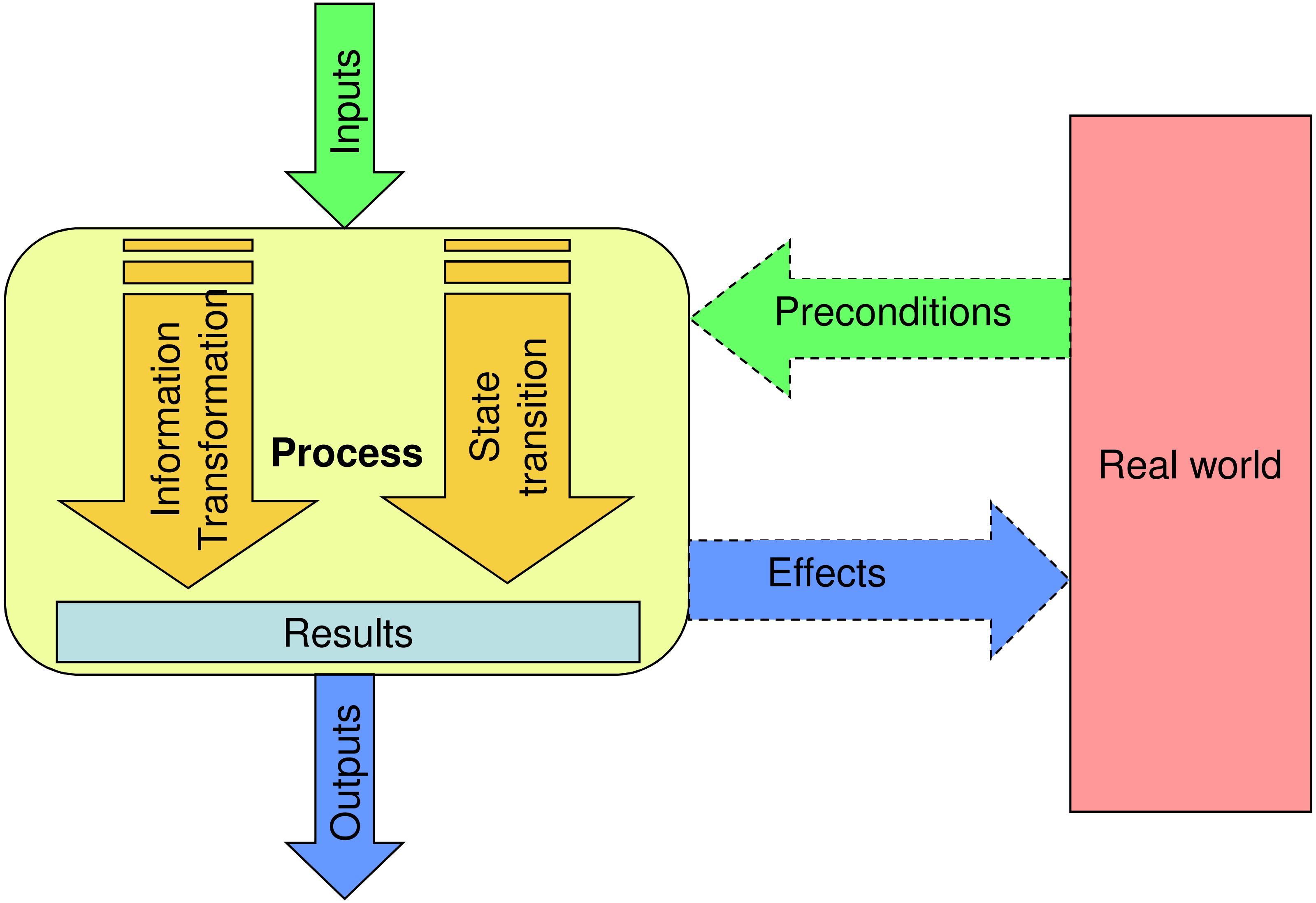
Mapping between OWL-S and WSDL

http://www.ai.sri.com/daml/services/owl-s/1.2

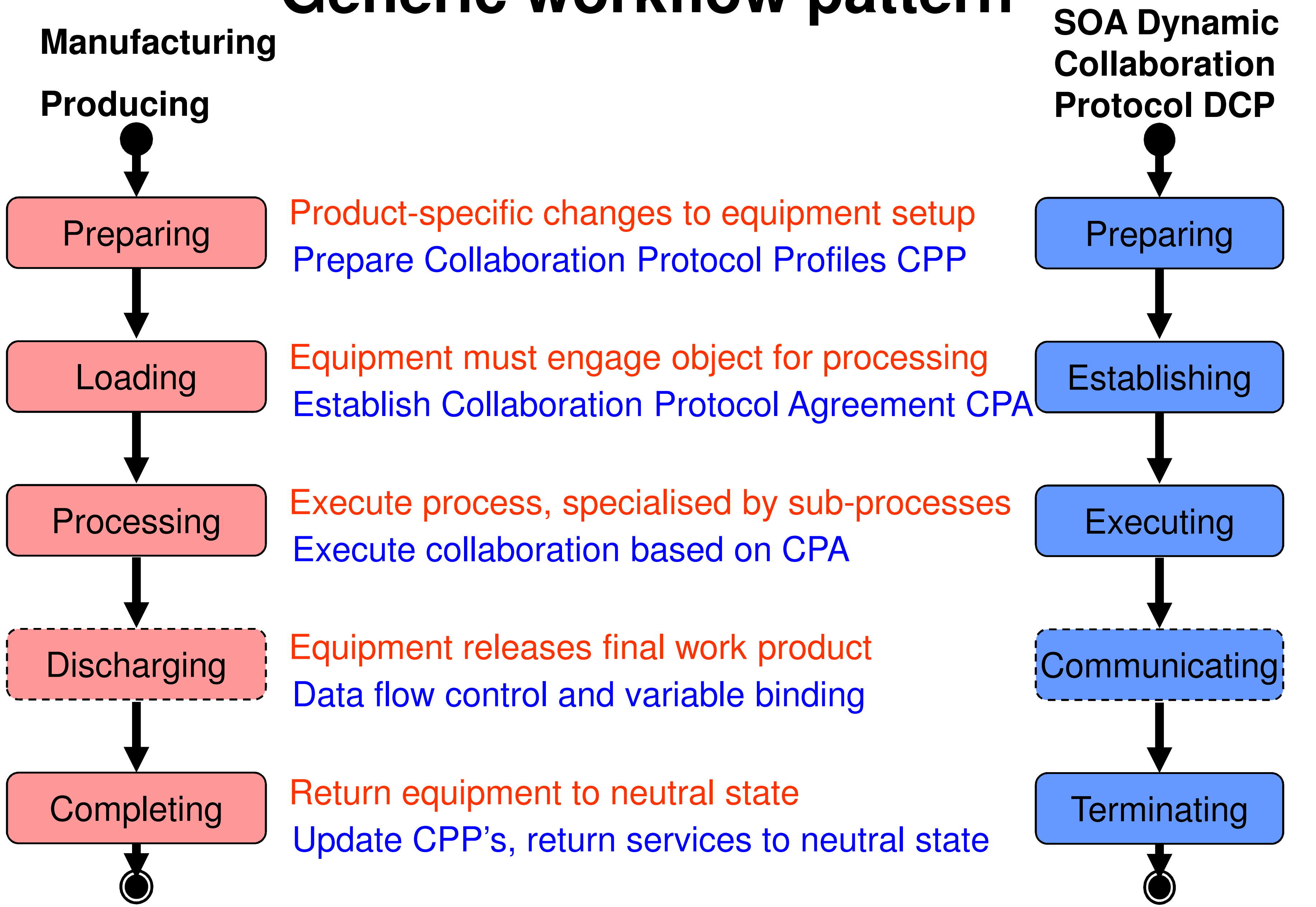


http://www.w3.org/TR/wsdl

Basic Manufacturing Process or Service Process Model



Generic workflow pattern



Ontology-enhanced SOA

- **OWL is developed as a vocabulary extension of RDF (Resource Description Framework) and is derived from DAML+OIL**
- **OWL was enhanced with a Web Services Ontology to define OWL-S**
- **OWL-S demonstrates basic similarity of Web Services collaboration patterns to Manufacturing workflow processes.**
- **Other ontology-based Services definitions:**
  - FLOWS: First-Order Ontology for Semantic Web Services
  - PSML (PSML-P, PSML-S and PSML-C): Model-Driven Policy Language
  - Pi4SOA: Policy Infrastructure for Service-Oriented Architectures
  - ISO-18629 PSL: Process Specification Language for Industrial Automation of Discrete Manufacturing processes
- **Frameworks that have formally defined Semantics, but are not in conformance with axioms defined in an underlying Ontology:**
  - ISA– 88.01–1995: Batch Control Part 1: Models and Terminology
  - ISA–95.00.01: Enterprise-Control System Integration, Part 1: Models and Terminology
  - PSLX: Process Specification for Advanced Planning and Scheduling

Potential of Ontology-enhanced SOA: World Class Manufacturing

- **No compromise on process safety or product quality**
  - Explicit Conceptual Function Specification (CFS) via a Service Model
  - Verification of CFS via workflow model simulation of Service collaborations
  - One-to-one validation of functional project deliverables against the CFS
  - Robust corporate governance of control system implementations and MES integration at all plants
- **Autonomous systems with human intervention by exception**
  - Automatic, dynamic process adjustments to variability of raw material
  - Performance benchmarking for global manufacturing plants
  - Streamline and guide fault diagnostics, minimize production downtime
  - Support of 6-Sigma DMAIC approach
  - Leverage in-depth analyses of knowledge for process improvement
- **Agile Planning and Manufacturing:**
  - General, Site and Master Recipes automatically transformed to fit actual resource capabilities at multiple plants on a global scale
  - Dynamically reconfigurable multi-routing of process streams
  - On-the-fly rescheduling during unforeseen disruptions of production

Potential of Ontology-enhanced SOA: Demand-Driven SCM

- **Seamless integration of sales, warehousing, distribution, manufacturing and supply chain**
  - Rule-based planning using real-time knowledge of national grid status for customer demand, supply capacity, manufacturing capabilities and distribution logistics
  - Optimized local workflow scheduling for each manufacturing site
  - Material flow control, process monitoring and genealogy traceability
- **Value-stream optimization based on real-time knowledge**
  - Promised deliveries realistically related to inventory & supply lead times
  - Realistic dynamic modeling of plant capability, resource capacity, equipment status, asset utilization and asset care strategy
  - Financial comparison per brand, geographical area, plant performance, etc. at a global corporate level

Stumbling blocks to Semantic Web usage in the Manufacturing domain

- Low general awareness of the potential of ontology-based applications and collaboration of Semantic Web Services.
- Semantic web and domain ontologies receive focus from academia and special interest groups, but not mainstream developers.
- Human resources with semantic web design and ontology development skills are scarce.
- Development support tools for RDF, OWL and OWL-S technologies are still immature.
- Use of ontology concepts in the manufacturing domain is very low.
- Corporate businesses have strong reliance on a chosen single vendor or minimum of software vendors to "deliver interoperability" of business information – "there *must* be a silver bullet in IT".
- Business process domain experts shy away from the explicit definition of their information needs – they would rather hand the task to IT.
- Concise, contextualised business information available in real-time challenges operations personnel to react effectively to dynamic events - management accountability is explicit.
- The requirements of credibility of source data and event triggers to feed automatic KPI calculations challenge the production personnel to improve the consistency of their work practices – it demands absolute diligence.

Conclusion

- **Comprehensive capability for workflow modelling is embedded in OWL-S Web Services.**
  - OWL-S workflow pattern corresponds to similar Equipment Process State Model already in use in Manufacturing execution.
  - Similar structures and relationships require less effort to obtain interoperability of heterogeneous systems.
  - Extension to Supply Chain Management and eCommerce services.
  - Generic pattern of a meta-model for workflow helps to improve our understanding and acceptance of Ontologies and Semantic Web Services.
- **Governance framework for Good Manufacturing and Business Practices**
  - One base model for Batch, Discrete and Continuous manufacturing.
  - Enforce manufacturing rules and regulatory compliance.
  - Seamless integration from Manufacturing to ERP and SCM processes.
  - A set of Manufacturing ontologies will play a vital role.

Questions?

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