
Technologies for Adaptive Supply Networks

An Overview of Current Research at CSIRO

Adaptive Supply Chain Strategies Conference, November 2003



CSIRO Mathematical and Information Sciences

Introduction



Adaptive Supply Networks

- ASN: A network of business partners who cooperatively and collaboratively perceive and adapt to the challenges in their environment.
- Out: Local planning, passive monitoring and reactive execution.
- In: Sustainable many-to-many business relationships, collaboratively-networked planning, proactive monitoring and adaptive operations.

CSIRO

- CSIRO is Australia's largest scientific research organisation and has around 6500 staff
- CSIRO Mathematical and Information Sciences (CMIS) and the CSIRO ICT Centre carry out research in many areas including:
 - Software architectures and components
 - Enterprise data mining
 - Operations research
 - Statistics
 - Collaborative work and tele-collaboration
- Adaptive Supply Networks R&D in CSIRO draws on this expertise.



Motivation for ASN

- Increasing global, agile and dynamic business operations
- Industry needs
 - Manage complex relationships and interactions between all supply chain partners
 - Collaboratively plan/schedule operations
 - Proactively monitor and adapt to changes
- Drivers
 - Expected productivity improvements
 - e.g. manufacturing productivity growth up to 45% with supply chain optimisation in eight years (Forrester, 2002)
 - Market growth
 - E.g. SCM market for new applications projected to grow 32%/year up to \$21.1b in 2005 (AMR Research, 2002)

Outcomes and Benefits

- More effective planning, coordination and utilisation of resources and services in complex collaborative business networks
 - Better relationships and enhanced collaborative participation
 - Better communication and decision-making
 - Better ways to manage disruptions and risks
- Potential benefits
 - Controllable, robust and efficient operations
 - Activity coordination across enterprises
 - Value, certainty and competitive advantage for all participants

SCM Trends

- Enabling Technologies
 - Global connectivity (Web, Internet, Intranets)
 - E-business (marketplaces, procurement, sourcing)
 - New models (SCOR, virtual enterprises, collaborative business, real-time supply chain monitoring)
 - Software and communication standards (Java, XML, agents, Web-services)
 - Advanced decision support and optimisation tools
- Uptake and adoption
 - New solutions offered/marketed by leading SCM vendors
 - Most Global 3500 companies started to exploit new technology solutions to improve performance of their supply networks (Forrester, 2002)

Foundations of ASN R&D



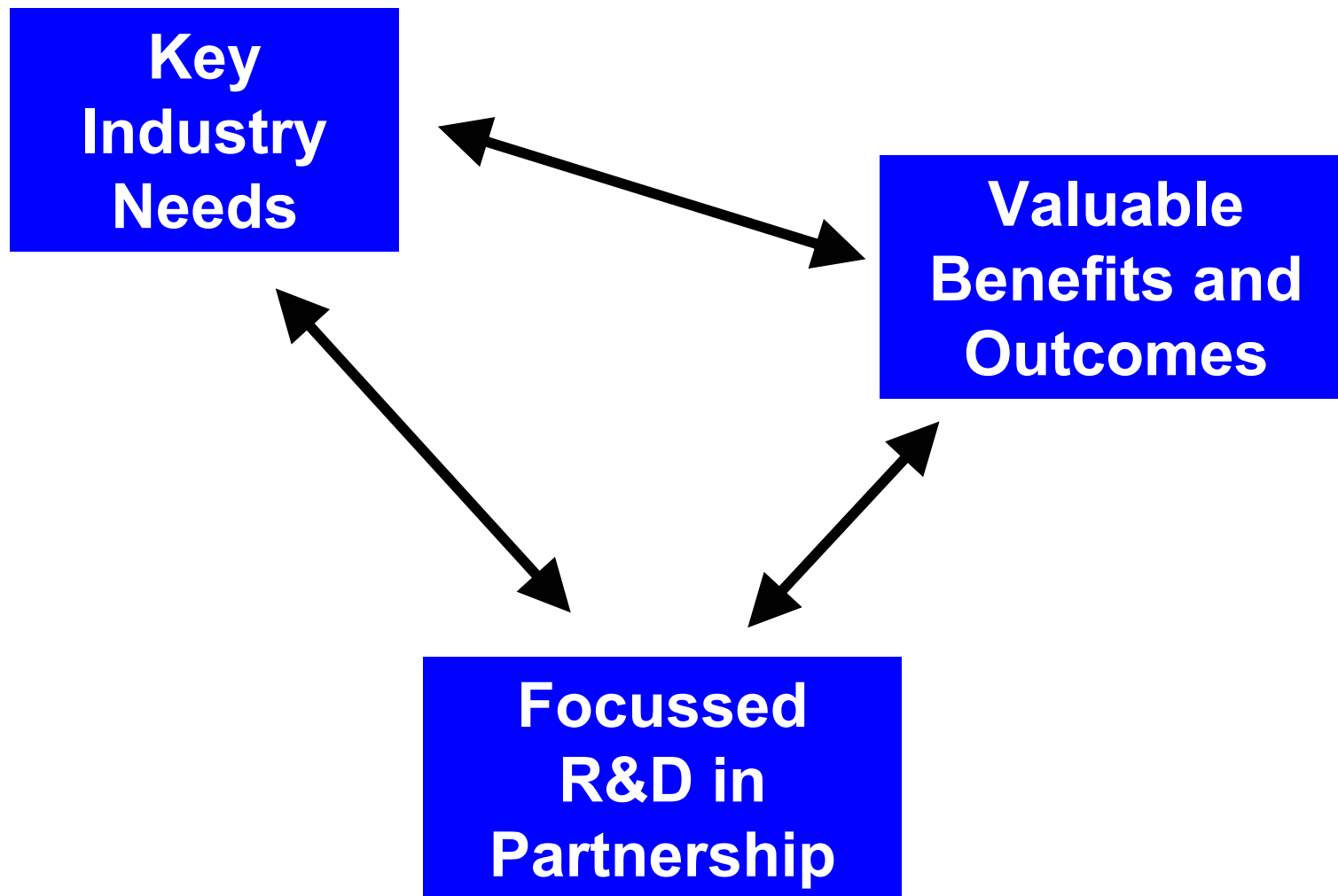
R&D in ASN Technologies

- Adoption of ASN technologies will deliver significant competitive advantages:
 - Growth through opportunities made possible by flexibility and responsiveness
 - Wealth through efficient resource utilisation and ideal management of the material and intellectual assets in the supply network.
 - Effectiveness through collaboration, understanding and visibility
- Some of these technologies can only come about through innovative R&D partnerships

CSIRO's Goal in ASN R&D

- Use our unique position to research and develop technologies that:
 - are crucial for ASN in certain industry sectors
 - are not available in existing SCM products nor addressed by prevailing SCM practices
 - complement and work with other SCM tools
- R&D Partnerships: work with industry to create and deploy ASN technologies
- Prove that ASN is the way forward

Engagement Approach



Key Industry Needs

**Collaborative
decision making
in complex
systems with
multiple
stakeholders**

**Trusted
collaborative
decision-making**

**Active
consideration of
multiple, co-owned
and conflicting
stakeholder goals**

- Determined through industry engagement

Research and Development

Planning, scheduling
and disruption
management in multi-
participant systems

Modelling, analysis
and process-design for
trust and perceptions

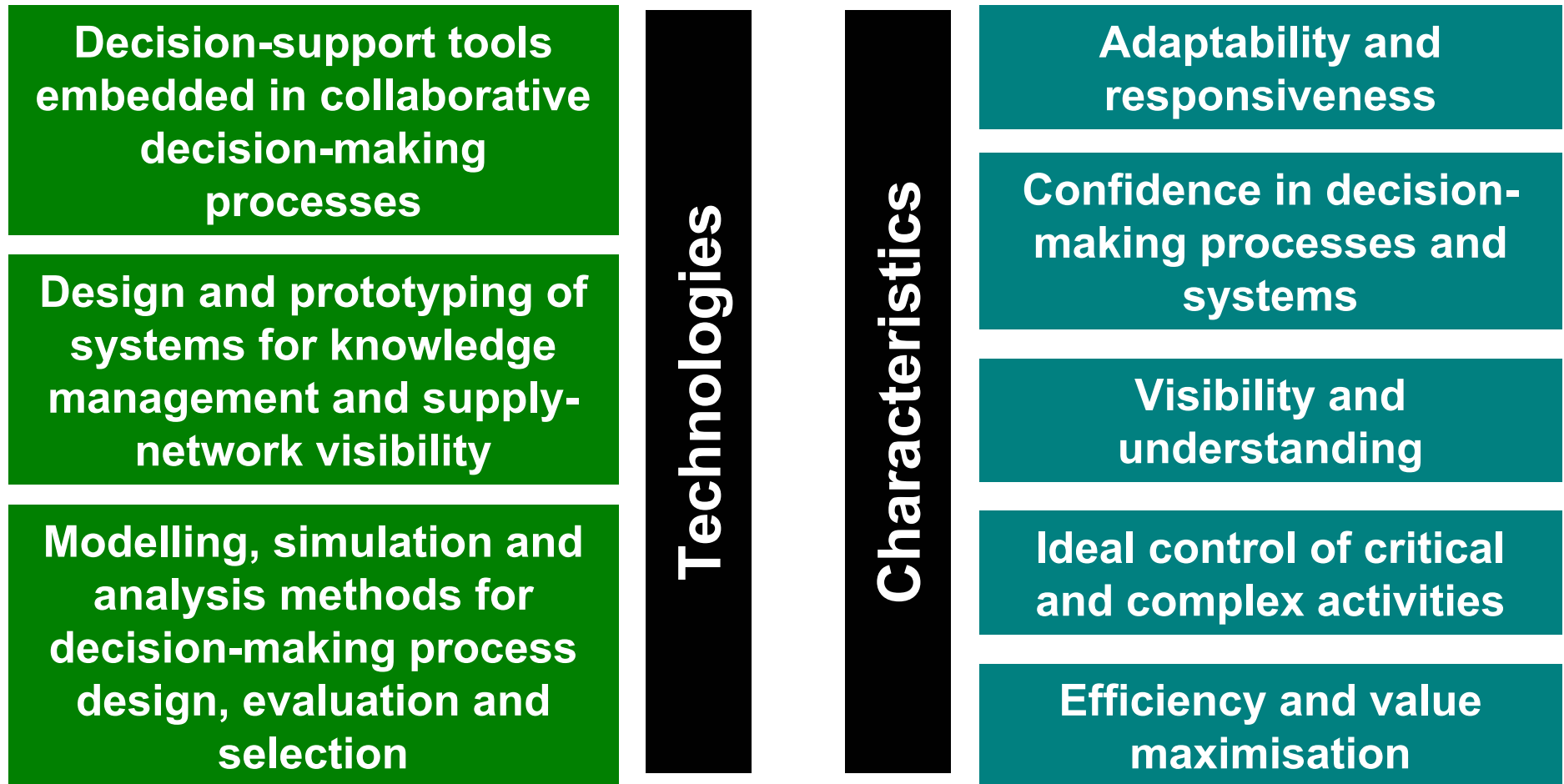
Modelling, representation
and resolution of multiple
objectives and goals

Rule and knowledge capture,
decision process design,
information display and
visibility

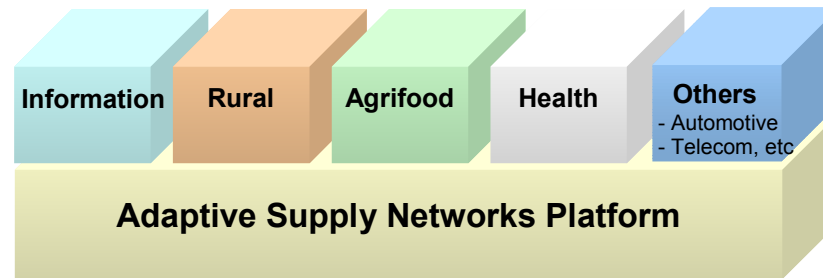
- Targeted at industry needs and utilising CSIRO strengths



Outputs and Outcomes



Technology Platform



- Decision-making software, modelling and analysis tools, collaboration tools
- Generic ASN platform and industry-specific tailored solutions
- Considerable initial emphasis on information services, agri-business and health

Technology Examples

- Technology:
 - to gather and display information in a way which promotes informed decision-making
 - to ‘embed’ reasoning in specific decisions
 - to proactively combat operational problems
 - for contributing to supply network visibility
 - that harmonises cross-enterprise plans
 - that makes and/or assists in decisions
 - that earns and engenders stakeholder trust in a system and its decision-making actions

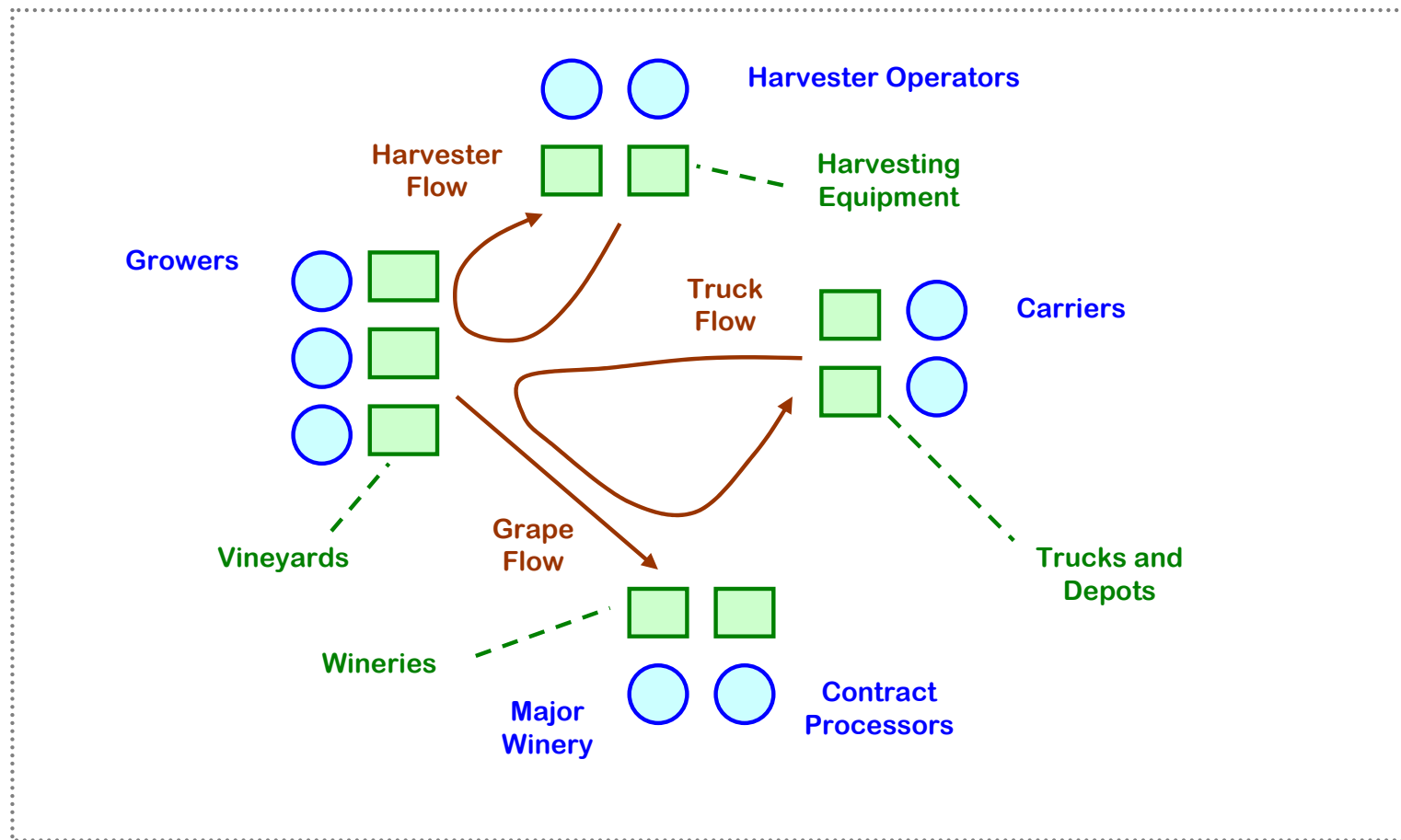
Research Underway

Perishables Logistics

- Major R&D focus on coordinating activities in agri-business supply networks
- Collaborative business-to-business processes for the planning and execution of logistics activities (e.g. harvest)
- Maximum potential value of the perishable asset (e.g. grapes, milk) can only be realised through efficiency and adaptability throughout the supply network

A Complex System

- Harvest logistics in the wine industry, for example, is detailed and complex.



Activity Coordination

- The problem of coordinating the activities is complicated by:
 - Numerous stakeholders and active decision-makers who are geographically distributed
 - Timeliness, accuracy and completeness of information
 - Interfacing tightly-controlled and capacity-constrained manufacturing with unpredictable farming and harvesting processes.
 - Appreciable variety in produce, product and value
 - Perishable asset deterioration caused by imperfect handling and adverse environmental conditions

Challenge

- Maintenance of competitive advantage relies on continuous improvement in value extraction (quality, quantity, opportunity)
- Activity coordination is critical
- On an industry-wide scale the coordination problem can only be wholly addressed using multi-party information exchange and advanced computational techniques for collaborative planning and scheduling.

Key Issues

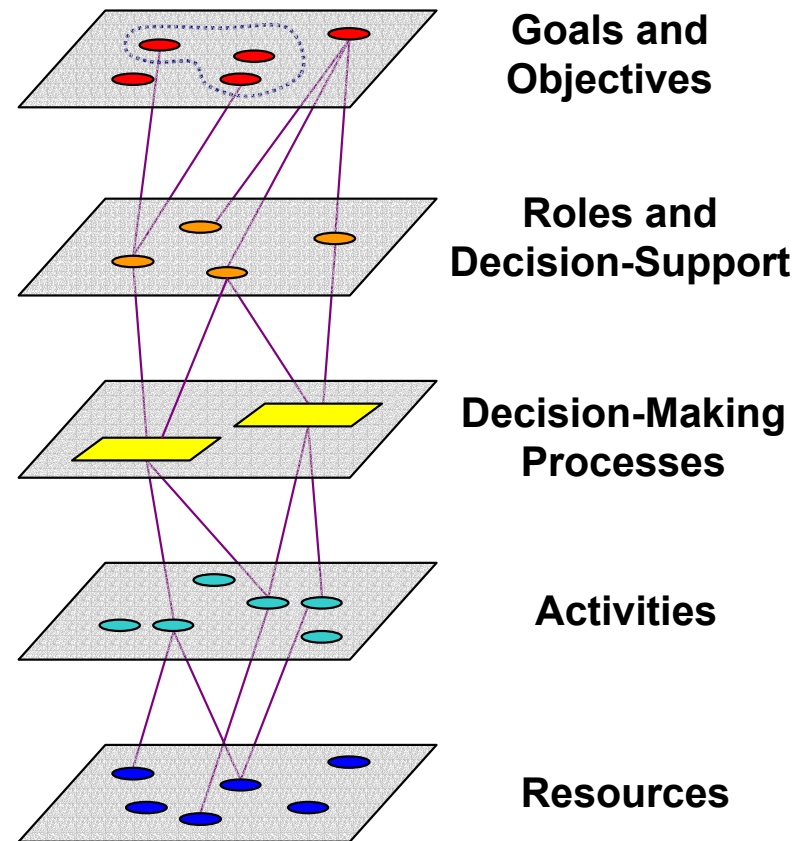
- Perishables: ripening times, critical attributes, allowable mixtures and so on
- Information: accuracy and timeliness, centralised data versus distributed agent-based systems
- Conflicts: multiple stakeholders motivated by common goals but also by own interests
- Trust: beyond data integrity and security, to trust in the intent and actions of a decision-making system

Collaborative Scheduling

- CSIRO research in Collaborative Scheduling (CS):
 - exploring a fundamental research question: the advanced computational techniques
 - ‘Problems’ motivated by practical optimisation experience, e.g. in coal supply chains
- CSIRO partnership R&D:
 - In the CS space we are currently addressing perishables logistics

Modelling for CS

- Careful and detailed modelling is required
- Perishables logistics calls for additional detailed modelling, e.g. state transitions over time
- Formal encoding of 'layers' becomes necessary.
- Tradeoff between detail and complexity.

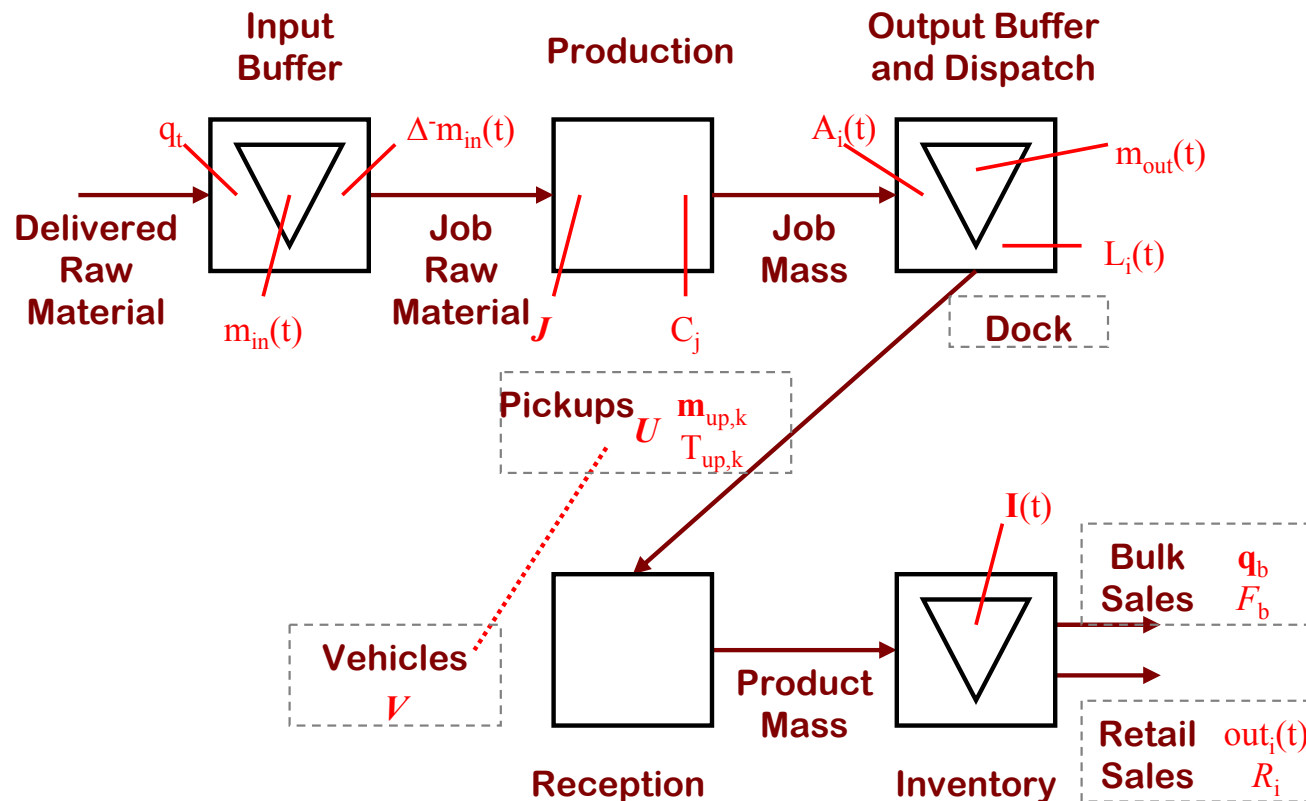


CS Techniques

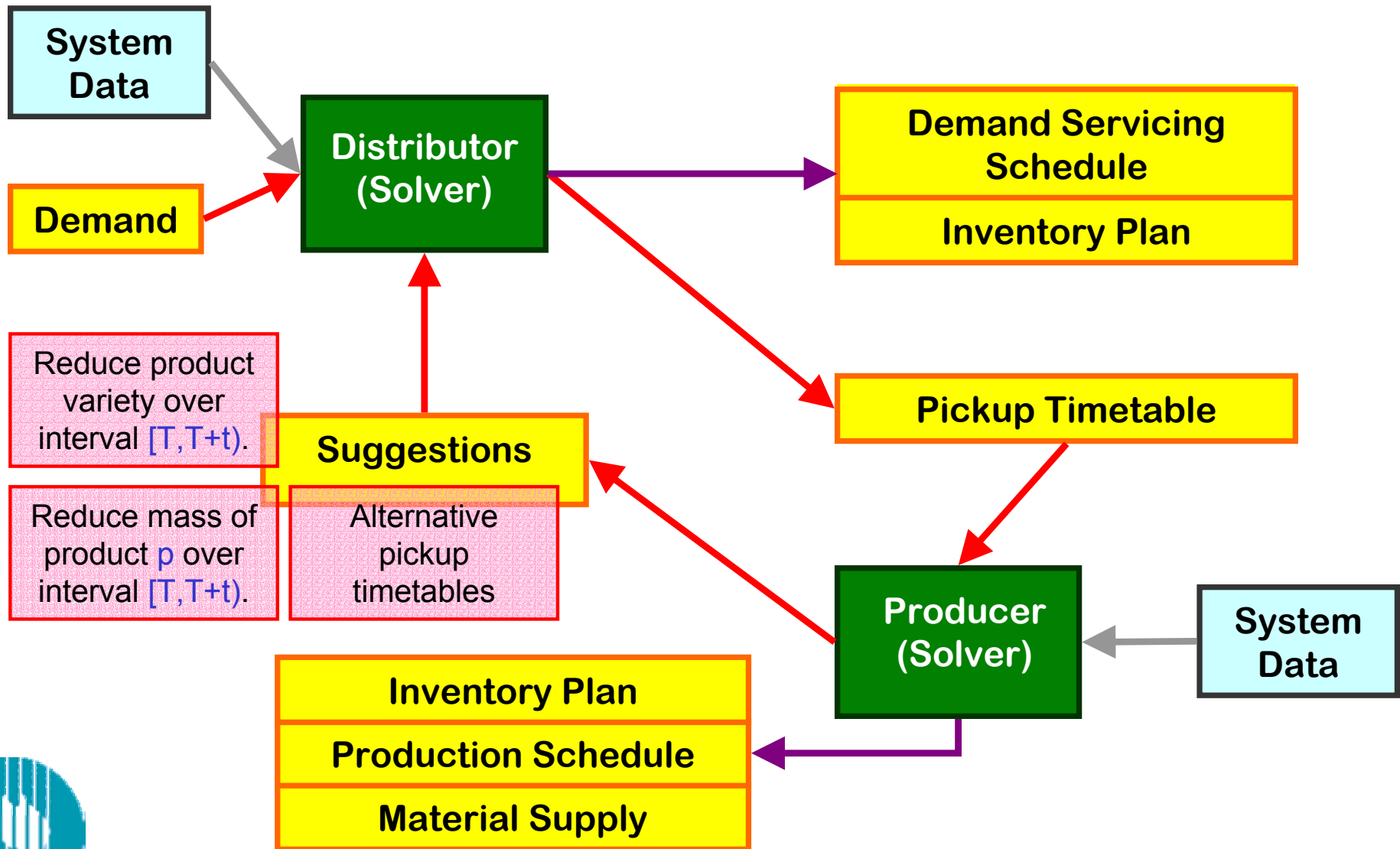
- Solution techniques for collaborative scheduling problems – leading-edge Operations Research
- Key idea #1: negotiation based on the timetable for supply of goods or services
- Key idea #2: the demand on a facility is not static, rather it is negotiated between the facility and its customers.

A Simple Example

- The producer-distributor model is a simple example that we use as a test-bed for research ideas.



Solution Framework



Research GUI

The screenshot displays a complex research GUI with several interconnected windows:

- Distributor Dashboard:** Contains a menu (File, Edit, View, Operation, Tools, Help) and a table of suggestions. The table has columns for type, importance, location (lo), time (hi), and product weights.
- Negotiable:** A window for managing 'negotiable 1' with buttons for 'Add New', 'Add Copy', 'Delete', 'Clear All', and 'Add New'. It features a table with columns: Pickup, Time, Quantity, and weights for Product 100, Product 101, and Product 102.
- Producer Dashboard:** Includes a menu and a 'Physical System' window with tabs for 'timestep', 'horizon', 'productinfo', 'inputbuffer', 'outputbuffer', and 'production'. It has buttons for 'Add new Product' and 'Delete Product' and a table with columns 'id' and 'mass'.
- Schedule Chart:** A Gantt-style chart titled 'outputbufferschedule' showing tasks for product 100, 101, and 102 over time. The x-axis represents time from 00:16:40.000 to 00:16:40.100. The legend indicates Egress (blue square), Ingress (red square), and Production (blue square).



A More Elaborate Example

- Motivated by our experience in delivering simulation and optimisation into the coal supply chain
- Timetable trains to meet (discrete) export shipping demands, while simultaneously developing operational schedules for rollingstock and crews.
- Thorough test of mechanisms for coordinating a complex multi-player system

The Role of Trust in CS

- In practice, stakeholders will accept and participate in collaborative processes only if they:
 - Trust that the correct processes get initiated and will complete in good time
 - Trust that their data will be used appropriately
 - Trust that they are seeing truthful and timely information from others
 - Trust that the system will protect and promote their interests when it acts on their behalf

Trust Modelling

- Trust is an important topic in our research.
- For the perishable logistics R&D, it is vital that we deliver systems that all of the numerous stakeholders have trust and confidence in.
- A major research effort in trust is concentrating on the health sector.
- Long-term goal is to reliably assess and compare processes on trust grounds

Summary

Adaptive Supply Networks

- The ASN 'revolution' is characterised by:
 - many-to-many business relationships, collaboratively-networked planning, proactive monitoring and adaptive operations.
 - flexibility, responsiveness, adaptiveness
- ...and driven by:
 - effectiveness, growth and wealth
 - maintaining competitive advantage

Current Research at CSIRO

- Collaborative planning and scheduling
- Understanding trust in decision-making processes
- Representing, considering and resolving multiple/conflicting objectives
- Information sharing strategies to support decision-making: innovation in knowledge exchange and supply-network visibility

CSIRO's Goals in ASN

- CSIRO's goals in ASN R&D are:
 - to tackle the difficult and complex decision-making problems that must be overcome if critical national industries are to progress
 - to share the R&D risk and reward with industry partners
 - to help to prove the benefits of ASN to the wider industrial audience
 - to foster innovation and informed decision-making in Australian industry