Model-based Communication Networks and *VIRT*:

Filtering Information by Value to Improve Collaborative Decision-Making

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Rick Hayes-Roth
fahayesr@nps.navy.mil

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“Houston, we have a problem…”

Net-centric operations have some challenging requirements:

- Joint, coalition, ad hoc operations “integrate seamlessly” and “share a common understanding”
- Each operator gets all needed information
- Cycle times drastically reduced
- Cooperating units self-synchronize

Fallacy:

plentiful information &
unlimited bandwidth
will make it so

Challenges to Decision-making

- Increasing number of partners/collaborators
- Increasing number of information sources and amount of available information
- Shrinking decision times in response to agile adversaries

People can't make good decisions when they are time-stressed and overloaded with information

The Basic Ideas

1. Synchronize groups by having them operate on semantically aligned and high-value information
2. Determine what concepts operators' missions depend on and make those standard
3. Notice what beliefs underlie mission plans and COAs
4. Automatically inform operators when data changes affect their beliefs and plan rationales
5. Create an open market for delivering valued information to users
   - Allow new suppliers to plug in sources they claim address important concepts
   - Allow users to modify concept requirements
   - Allow users to reward/punish (feedback) suppliers based on results
   - Allow reputations to develop that influence purchase and use of information

Model-based Communication Network (MCN)

- **Instead of Stateless Networking, State-full**
  - Maintain shared state among collaborators
  - State = current values of models, *e.g.*
    - The route plan, position, velocity of an aircraft
    - The current and future position and behavior of a unit
    - The hypothesized position, status and intention of a system
- **A shared world model is the goal**
  - Collectively, what the collaborators believe
  - Distributed, replicated for efficiency
  - Autonomously updated, through dead-reckoning
- **Like a distributed blackboard of hypotheses**
  - Re-conceptualize Common Operational Picture
  - Obviate “communication” of non-news
  - Emphasize “information,” especially valuable information

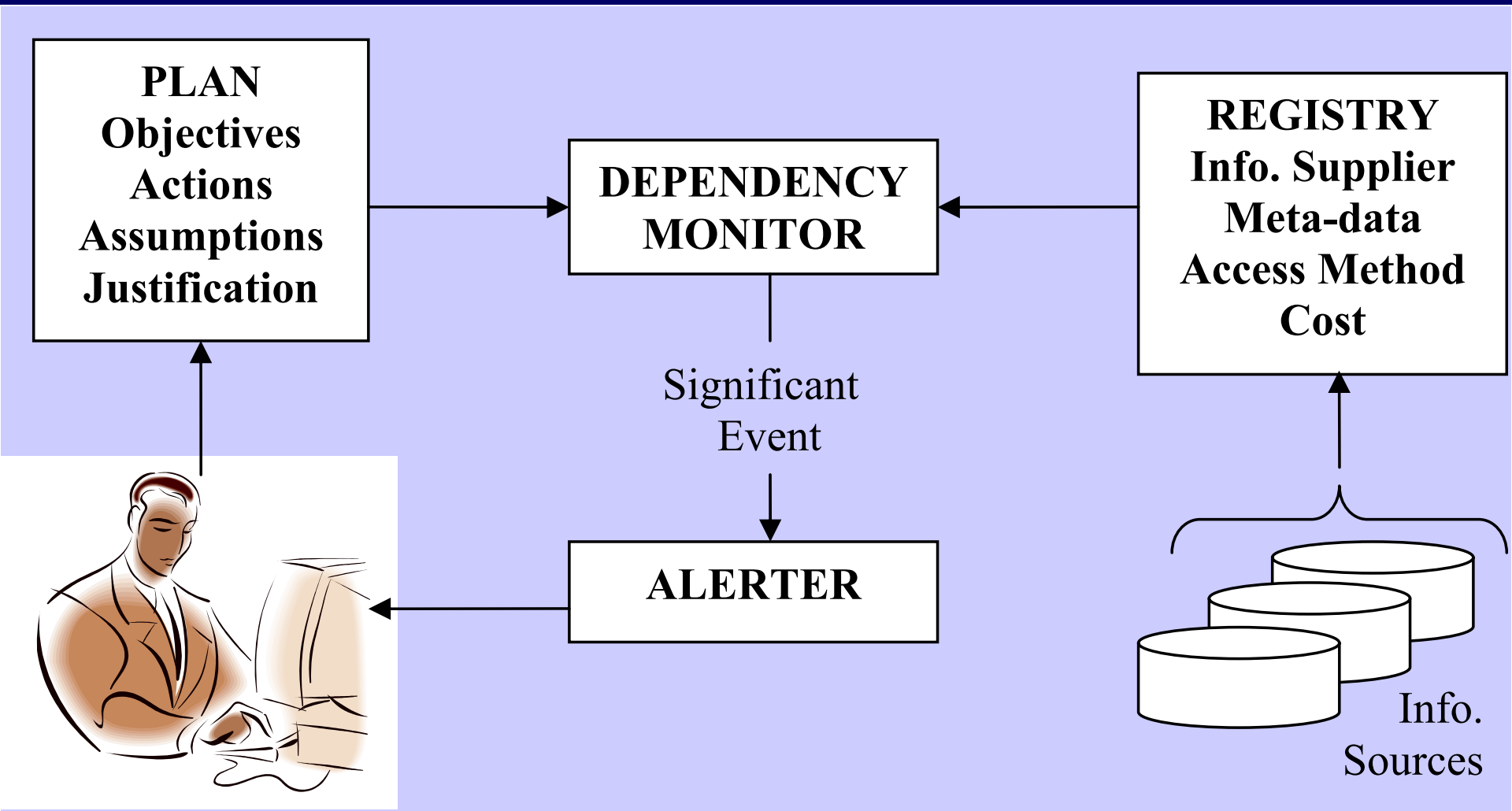
Some Examples

1. **Pilots need weather information.**
   - Planning, Monitoring, Executing phases
   - Mission phases: Take-off, En Route, Descent, Approach, Land
   - Phase-specific risks
   - Weather information affects risks
   - Operator preferences alter risk assessment
2. **SEALS need weather information**
   - Similar to above, but phases: approach, swim, land, …
   - Weather affects risks, such as detection

Valuable Information at the Right Time (VIRT)

- Most information suppliers today mass produce information products
- Decision-makers want "news" that "materially affects" their expected results
  - This operationally defines "valuable information"
- Ideally, information flows prioritized by expected impact on the recipient
  - Differs from their beliefs, significantly
  - Undercuts the rationale for their current plans
  - Alters their plans and behavior
  - Improves their (expected) outcome
- Suppliers "know" their customers
  - Determine which info they value and deliver it

A Simplified VIRT Process Model



A VIRT Product-Line Architecture

Planning Toolset

Key Assumptions

Plans

Plan Generator

Plan Evaluator

Plan Justifier

Dependency Analyzer

Condition Generator

Plan Updater

Condition Monitor

Condition (t, loc)

Significant Deltas

Agenda for Updates

Condition Alerter

Concerned Parties

History of Alerts

Notification Methods

Operational Domain Ontology

Concepts

Conditions

Significant Deltas

Domain Translator

Conditions

Significant Deltas

Information Registry

Information Source

Meta-data

Qualities/Cost

Access/Query Methods

Information Domain Ontology

Concepts

Conditions

Significant Deltas

Principal Remaining Challenges

- Need practical ontologies for important domains
  - We are developing a rich semantic model of *Track*
    - A common "informal" concept in military operations
    - Now vital in multiple domains: aircraft, ships, vehicles, people, cargo, …
    - Semantic hub + translator generators => information sharing
- Leading communities need to transform around VIRT to MBE-style
- Need open, evolutionary markets for info suppliers and customers

The Rich Semantic *Track Model*

- ***Track***
  - **Beliefs**
    - **Identity and Characteristics**
    - **Dynamic State at Time T**
    - **History of states (past "track")**
    - **Predicted states (future "track")**
  - **Meta-Information (applicable to each element of belief)**
    - **Evidence**
    - **Inferences**
    - **Error and uncertainty estimates**
    - **Temporal qualifications**
    - **Spatial qualifications**

The top-level conceptual hierarchy for *Track*.
The full hierarchy has more than 125 high level concepts.

Near-Term Exploitation Opportunities

- DOD organizations and other agencies (e.g., FAA) reengineering business around VIRT
  - "Supply-chain management" comes to information market
  - CEC, *Track Model,* and network enterprise service for Track Management
- NCOIC & W2COG are embracing VIRT as a central tenet
  - Geoff Brown, Dir. Adv. & Emerging Tech., Oracle, is partnering with us
- DOD's NII has the concept of "communities of practice"
  - Could lead to community models
  - Could lead to re-conceptualizing COP into a "dynamic world model"
- Federal Enterprise Architecture Data Reference Model
  - Mike Daconta, DHS, author of *Semantic Web,* now leading meta-data effort

Conclusion

- New problems and new opportunities combine to change our concept of
  "collaborative communication networks"
- Humans need to apply computers to reduce information glut
- Collaborators need to develop and use common models and share model state
- A consumer's beliefs and plans determine the value of information
- Computers can implement knowledge of decision-makers and current state to determine the flow of bits
- Significant increases in productivity will result