Knowledge as Inventory: Near-Optimizing Knowledge and Power Flows in Edge Organizations

Doug MacKinnon
Advised by: Dr. Ray Levitt and Dr. Mark Nissen
http://crgp.stanford.edu
ICCRTS Paper: 083

Acknowledgements: OASD-NII/CCRP and Center for Edge Power
Agenda

- Motivation
- Conceptual Model
- Research Questions
- Inventory Theory
- Knowledge as a Perishable Good
- Agent Knowledge Metric
- C2 Applications
- Next Steps
- Theoretical Contributions
Motivation

- **Edge Organization definition**
  - No headquarters to rely upon
  - Requires: shared awareness / self synchronization

- **Knowledge flow is especially critical for Edge Organizations**
  - High levels of strategic & operational knowledge needed at nodes
  - Enables “agility” in an uncertain environment
  - Understanding knowledge growth & decay in Edge organizations - critical for optimizing performance

- **Research Goals**
  - Develop conceptual model of knowledge flows
  - Validate and embed in computational models for organizational simulations
Conceptual Model

- Consider inventory theory for perishable goods as a metaphor to inform knowledge and power flows in Edge Organizations
  - Inventory Theory
  - Knowledge Inventory
Research Questions

- **Phase I:**
  - How can MS Inventory Theory help to inform our understanding of knowledge flows in Edge Organizations?

- **Phase II:**
  - How can MS Inventory Theory, adapted to account for differences, extend current organizational design simulation models?
Inventory Theory: Analysis and Insights
Logistics Manager’s Perspective

- For a supply chain of perishable goods, managers gain insights considering:
  - Economic Order Quantity (EOQ = Q*)
  - Reorder point
  - Make vs. Buy decisions
  - Inventory policies
    - Just-in-Time
    - Just-in-Case

\[ Q^* = \sqrt{\frac{2K\lambda}{Ic}} \]
Perishable Goods in a Supply Chain vs. Knowledge in an Organization

- Similarities
  - Knowledge is a critical resource
  - Knowledge demand is difficult to forecast
  - Knowledge stores can be increased
  - Knowledge stores can be decreased
  - Knowledge can be distributed
Perishable Goods in a Supply Chain vs. Knowledge in an Organization

**Differences**

- Knowledge is a collective (public) good—vs. produce
- Knowledge when demanded creates more knowledge
- Knowledge “holding costs”
  - Individually may be negligible—vs. security, refrigeration, rent
  - Underutilized experts however may be very expensive
- Knowledge is difficult to quantify—vs. produce
Agent Knowledge Metric (k/K)

- Fraction of relevant knowledge possessed by agent (k) versus the knowledge available in a certain field (K).

- Metric changes
  - Type, amount, recency of learning (OJT, mentoring, etc.) — ↑k
  - Knowledge obsolescence (environment) — ↑K
  - Decay (time, interference) — ↓k
C2 Application

- Knowledge as inventory provides framework
- Example: Watchstander training (deployment preparation)
  - Consider EOQ model
    - Increased subtractions (\(\downarrow k\))
    - Decreased additions (\(\downarrow k\))
    - Uncertain environment (\(\uparrow K\))
    - Safety stock
    - Less time for training requires a longer lead time
    - Frequency and magnitude of “reordering” increases to maintain proficiency

\[
Q^* = \sqrt{\frac{2KL}{Ic}}
\]
C2 Application Insights

- **JIT vs. JIC**
  - Specialist
    - Longer lead time, but knowledgeable
  - Generalist
    - Shorter lead time, but not an expert

- **Material Resource Planning (MRP)**
  - Building upon earlier training
    - Basic to advanced
    - OJT to mentoring
Next Steps

- Proposed Extensions to POW-ER Computational Modeling Framework
- Develop framework to account for agent knowledge
- Develop fine-grained agent knowledge metric (k/K)
- Provide for dynamic knowledge over time
Theoretical Contributions

- **Phase I**
  - New knowledge concerning how inventory theory can inform knowledge flows in Edge organizations
  - Development of Knowledge Metric (~% k/K)
  - Exploration of “Knowledge Chain Management” principles (~ Supply Chain Management)

- **Phase II**
  - Extend the capability of computational modeling to reflect optimally contingent knowledge flow in Edge and other organizations
Knowledge as Inventory: Near-Optimizing Knowledge and Power Flows in Edge Organizations

Doug MacKinnon
Advised by: Dr. Ray Levitt and Dr. Mark Nissen
http://crgp.stanford.edu
ICCRTS Paper: 083

Acknowledgements: OASD-NII/CCRP and Center for Edge Power

ICCRTS Conference — McLean, VA, June 13-16, 2005 — Power to the Edge Track