Automated Workflow Reconstruction for C2 Experimentation

Dave Allen
Defence Research and Development Canada
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Outline

1. Command and Control Assessment Framework
2. Process Assessment Limitations/Issues
3. Automated Tool to Process Reconstruction
4. Evolution of C2 Assessment and Experimentation Methodology
5. Conclusion
Key Elements to C2 Assessment

• C2 assessment needs to include team and cannot be limited to a single individual.
  – “C2 deals with distributed teams of humans operating under stress and in a variety of other operating conditions.” D. Albert, COBP for C2 assessment. CCRP, 2002.

• Need to incorporate people, process, and technology and their interfaces:
  – Interfaces: People-people, people-technology, people-process, process-technology, etc.

• Assessment needs to go beyond controlled experiments and include observation studies where room is provided for agile behaviour.
NATO Command Team Effectiveness Framework (CTEF)
Relevant Models to Assess C2

• NATO SAS-065: C2 Maturity Model
  – Rough C2 classification based on distribution of information (outcome), patterns of interaction (process), and allocation of decision rights (condition).

• Decision-Making:
  – OODA Loop (Boyd)
  – Klein’s Recognition Prime Decision
  – Gigerenzer’s Fast&Frugal

• Group/Team Dynamic:
  – Ajzen’s Theory of Planned Behavior (Capability, Authority, Responsibility – CAR)
  – Webb’s factor for ineffective collaboration
  – Weick’s Contextual Rationality
Common Missing Ingredient: Expectation

- Impact on the perception of authority and validity of information!

(Mental models)

- Ignorance
  - Error
    - Distortion
    - Confusion
    - Inaccuracy
  - Incompleteness
  - Uncertainty
    - Absence
    - Ambiguity
    - Probability
    - Vagueness
      - Fuzziness
      - Nonspecificity
  - Irrelevance
    - Untopicality
    - Taboo
    - Undecidability

Process Analysis Issues

• Missing information flow data:
  – Direct information exchange through email, chat logs, phone easier to capture than indirect exchange.

• Increase used of complex C2 systems to transfer information.
  – Some with limited logs.
  – Acquired through FMS Case with limited access to modify.
  – Limited capability to interfere with database when in Secure mode.

• Various processes or instances of the same process occurring simultaneously.
Type of Processes Investigated

• C2 process in support of missions such as:
  – Fire support request
  – Troops in contact
  – Medical Evacuation
  – Close Air Support (including GCAS, XCAS)
  – Close Combat Attack
Process Capture and Mining Requirements

- Capture the processes performed by a distributed team of operators performing their work on computers.
- Capture context in which actions are performed (information available to the operators performing a given action).
- Allow replay of captured data in a synchronous manner.
- Support the search and mining of captured data.
- Support an autonomous identification of specific actions and the computation of statistics of sequence of actions.
- Support the comparison of expected vs. observed processes.
Terminology Used

- **Action**: Complete observable movement performed by an operator (e.g., striking a key, a set of continuous eyes saccade).
- **Task**: Activity that is accomplished by a single operator or performed simultaneously by a group of operators and which leads to a single output (e.g., producing a brief).
- **Approach**: Attitude or manner (modus operandi) to perform some task.
- **Method**: Way of accomplishing specific tasks.
- **Procedure**: Series of actions specifying a precise way of accomplishing a task.
- **Process**: Collection of causally related tasks, which solve a particular issue. It includes: the set of interrelated tasks; resources assigned to the tasks; the set of expected outputs or goals; the set of possible triggers (WorkFlow Net).
Data Capture

• The content of the audit trail includes:
  – Logs from communication tools (chat, email, phone, etc.)
  – All keytrokes time tagged
  – All mouse click time tagged + location in screens
  – Capture of screen snapshots at user specified intervals (~5 Hz).
Data Mining and Analysis Overview

Activity Models
Event-Trace Diagrams

Keystrokes
Mouse clicks
Screen Snapshots
Data Mining and Analysis Components

• An audit trail browsing component to review and vet the captured data;
• A text extraction component to identify the information content within the operators displays (from the screen snapshots);
• A search functionality to mine all extracted data;
• A tagging functionality to cluster and label particular actions;
• An association functionality to associate a set of actions with a given task;
• A results visualization module.
System Particularities

• Text Extraction: An Optical Character Recognition identifies screen snapshot contents (uses various transformation: Hough, Hue-saturation, etc.).

• Data Mining: Levenshtein distance used for including incorrect entries.

• Tagging: Both manual and automated tags. Leads to the clustering of associated events.

• Visualization: Gantt charts, Graphs, Networks
  – SNA based on communication logs
  – Time sequenced SNA
  – Operators statistical data
  – Comparison expected vs. observed processes
Visualization Examples
Process Capture and Mining

Benefits

• Benefits will include:

  – Improved investigation of team synergy and synchronicity (not always obvious to operators)

  – Testing of established Tactics, Techniques, and Procedures (TTPs).

  – Review of context leading to human errors.

  – Operators ability to review own actions and learn.

  – Support the expansion of the Canadian Forces Warfare Centre role from experimentation into organizational learning role.
Broadening the Experimentation Approaches

- Equivalence between software testing and experimentation methodologies:

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Importance of the Automated Analysis Tool

Key element to model-driven experiments.
Conclusion

• C2 is a complex socio-technical entity requiring a broad (people, process, technology) and careful assessment.

• Process assessment is difficult due to the distribution of the process, non-direct communication, and often lack of data.

• Contextual data is required for adequate interpretation and review of activities.

• Detailed manual analysis is possible for a small team of operator and short experiments but automation is needed in other situations.

• The automated process mining and analysis tool allows the testing of TTPs and the development of model driven experiments leveraging architecture framework models.
Questions?