The Monterey Phoenix Approach and Tool for Behavior Modeling

Kristin Giammarco, Ph.D.
Department of Systems Engineering

Mikhail Auguston, Ph.D.
Department of Computer Science
What is Monterey Phoenix?

• MP is a Navy-developed formal *approach* and *language* for modeling human, technology, and environment *behaviors* all in one modeling environment

  – The MP-Firebird tool is publicly available at [http://firebird.nps.edu](http://firebird.nps.edu)
Purpose of MP Modeling

• To answer questions about behavior
  – structure of behavior
  – dependencies between actions involved in the behavior
  – constraints on behaviors
  – simple queries about behavior
  – to provide a source for different visualizations or views of behaviors

“Simplicity does not precede complexity, but follows it.”
– Alan J. Perlis

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<tr>
<th>Prevailing problems</th>
<th>MP value proposition</th>
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<td><strong>Incompleteness</strong>: Only a very small subset of possible behaviors are modeled showing all actors and interactions on the same diagram</td>
<td><strong>Scope-completeness</strong>: Generates set of possible event traces (use case extensions) exhaustively up to a user-defined limit on iterations</td>
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<td><strong>Ambiguity</strong>: Behavior models describe general activities but are unclear about who is doing each activity, or are otherwise unclear about activities performed</td>
<td><strong>Separation of concerns</strong>: Behaviors are separated by actor, and interactions between events in different actors are separately layered on as constraints; modeling in MP enables discussion and clarification of the behavior logic</td>
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<td><strong>Inefficiency</strong>: People continue to do work that an automated computing device could do faster and with far fewer errors</td>
<td><strong>Efficient task allocation</strong>: Humans focus on using their experience, creativity, and pattern detection skills to inspect and evaluate, and use automated tools to compute, generate, and search</td>
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<td><strong>Unwanted behaviors</strong>: Built systems that may meet requirements, but also permit extra undesired behaviors</td>
<td><strong>Behavior pruning</strong>: Enforces the necessary model structure for exposing and purging unwanted behaviors in the design before they emerge in actual system</td>
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Things with Behavior

- MP is used to define logical or physical objects in terms of their underlying behaviors.
  - Human, technology, environment, etc.


https://biologydictionary.net/eukaryotic-cell/
• *Behavior* is defined as a set of events with two basic relations: precedence and inclusion
**Human**

- **Person** includes
- **Check weather forecast** precedes
- **Drive to work**

**Technology**

- **Smart Phone** includes
- **Fetch weather data** precedes
- **Display weather forecast**

**Environment**

- **Environment** includes
- **Rainy**
- **Sunny**
MP Language: Event Grammar

Person: Check_weather_forecast
   Drive_to_work;

Smart_Phone: Fetch_weather_data
   Display_weather_forecast;

Environment: (Rainy | Sunny);
A: B C;  Ordered sequence of events (A includes B followed by C)
A: (B | C); Alternative events (A includes B or C)
A: [B]; Optional event (A includes B or no event at all)
A: (* B *); Ordered sequence of zero or more occurrences of event B in A
A: (+ B +); Ordered sequence of one or more occurrences of event B in A
A: {B, C}; Unordered set of events B and C in A (B and C may happen concurrently)
A: {* B *}; Unordered set of zero or more occurrences of event B in A
A: {+ B +}; Unordered set of one or more occurrences of event B in A
MP Tool High Level Architecture

Public user

Internet

firebird.nps.edu

Web browser

MP Modeler

- Create a model
- Run the model
- Inspect scenarios

MP Tool

- Compile MP code
- Generate all possible scenarios in scope
- Display generated scenarios
The Small Scope Hypothesis: most flaws in models can be demonstrated on small counterexamples.

1. Type model here.

2. Run the model.

3. Inspect resulting event traces.

- Model system behaviors separately
- System interactions treated as constraints
- Exhaustive generation of SoS behaviors up to a specified scope
### Authentication Model Demonstration

#### Schema Authentication

```java
/* USER BEHAVIORS */

ROOT User: Provide_credentials (• CREDS_INVALID Reenter_credentials •) [ CREDS_VALID Access_system ];

/* SYSTEM BEHAVIORS */

ROOT System: Verify_credentials (+ ( CREDS_INVALID Deny_access | CREDS_VALID Grant_access ) +) [ Lock_account ]

/* INTERACTION CONSTRAINTS */

User, System SHARE ALL CREDS_VALID, CREDS_INVALID;

COORDINATE $o$: Provide_credentials FROM User
DO ADD $o$ PRECEDES $p$; DO;

COORDINATE $o$: Reenter_credentials FROM System
DO ADD $o$ PRECEDES $p$; DO;

COORDINATE $o$: Grant_access FROM System
DO ADD $o$ PRECEDES $p$; DO;

COORDINATE $o$: Access_system FROM User
DO ADD $o$ PRECEDES $p$; DO;

ENSURE #CREDS_INVALID <= 3;
ENSURE #Deny_access -> 3 <-> #Lock_account -- 1;
ENSURE #Grant_access -> 1 -> #Lock_account -- 0;

X Console — Generated 6 event traces

Completed S_a613a8f9352b8864132ed4810d01e2c01f; 6 traces (0 MARKed) 79 events
average 85333 env/trace min 4 max11
completed S_56333 ev/trace min 4 max11
completed S_53333 env/trace min 4 max11
completed S_11667 ev/trace min 9 max18
Elapsed time 0.04 sec, Speed: 17275 events/sec
0.04usystem 0.04user (Pavilion+Ovidxdata 91%CPU (Oavixtext+Oavidxdata 199maxresident)
0 inputs & 4 outputs (major+44minor) pagefaults 0 swaps
Finished Compiling! Graphing 6 event traces...```
Meaning of “Scope” in MP

The Small Scope Hypothesis: most flaws in models can be demonstrated on small counterexamples.
Example Emergent Behaviors Found Using MP Modeling

- An order processing system enters a waiting state after a transaction is cancelled. (Pilcher 2015)

- The International Space Station is unaware of a hazardous condition within a supply spacecraft as that spacecraft approaches to dock. (Nelson 2015)

- A first responder administers rescue medication to an unconscious patient, unaware that the medication was already administered. (Bryant 2016)

- A UAV on a search and track mission reaches a return-to-base condition, then finds and begins to track a new target. (Revill 2016)

- A UAV on a humanitarian assistance and disaster relief mission reports acceptable system status, then the operator suddenly commands the UAV to abort the mission without provocation (Reese 2017; Beaufait, Constable, and Jent 2017).

- A Pressurized Water Reactor experiences subsystem failures that cannot be traced to the source by the human operator. (Thrutchley, 2018)
How MP Works to Expose Unwanted Behaviors

“prune” objectionable behaviors

leave behind only the desired behaviors
What Has MP Been Used For?

Modeling UAV swarm behavior
(Launch, Ingress, Mission, Egress, Recovery)

Modeling a UGV mission
(Searching and clearing hazardous objects)

Modeling fuze behavior
(Specification to support LP/HC analysis)

Modeling MQ-25 missions and a surrogate
UAV system used for piloting SET

Modeling a business process (Non-DOD
conference approval process)

- MP has been employed in theses, dissertations, teaching, and sponsored research efforts to model behaviors for system architecture, software architecture, software-intensive systems architecture, business processes, biological processes, geological processes, human interactions, medical procedures, operational missions, and entertainment events

UAV: Unmanned Aerial System
UGV: Unmanned Ground System
LP/HC: Low Probability / High Consequence
SET: Systems Engineering Transformation
Main Body
- Motivation and Objectives
- Related Work
- Technical Accomplishments
- Conclusions
- FY18 Plans

Appendix A: List of Publications and Invited Talks
Appendix B: References Cited
Appendix C: Collaborator Courses that Integrate or Contribute Research Results
Appendix D: Monterey Phoenix Overview
Appendix E: Preliminary Catalog of Reusable Architecture Patterns
Appendix F: Instructions for Downloading UAV Models
Appendix G: Model Based V&V (MCSE MPT) Demonstration

Questions?

Monterey Phoenix and Related Work:

https://wiki.nps.edu/display/mp

firebird.nps.edu

kmgiamma (at) nps.edu