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Using Board Games as Subject Matter for Developing Expertise in Model-Based Systems Engineering

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Enhancing MBSE Learning

Motivation and Premise

Facilitate SysML Learning via Modeling of Familiar Games

- Model-Based Systems Engineering (MBSE) transition is formidable:
  - Practitioners must learn new languages, tools, and methodologies…
  - All while doing their normal jobs and managing expectations
- The Systems Modeling Language (SysML) is difficult to quickly learn
  - Practitioners typically must learn a subject matter while also learning a language and model methodology
- **Premise:** Well-understood games remove the need to learn a new subject matter while also learning to model
  - Learners can focus on becoming proficient modelers
  - Learners ask more questions about language subtleties than subject matter details

Game Characteristics Suitable for Modeling

- Characteristics of games suitable for modeling :
  - Multiple players, game pieces or markers, and conditions for winning or losing
  - Multiple types of interactions between players
  - Variable player roles, levels of difficulty, rules, or initial game set-up or conditions
- Several ubiquitous gaming mechanisms map nicely to standard modeling constructs, e.g.:
  - Trading ▶ Interfaces, constraints, and sequences
  - Variable Player Powers ▶ Variants, constraints, requirements, states, use cases, and allocation

A comprehensive example

Modeling Monopoly

Monopoly subject matter used with permission. Hasbro does not sponsor or endorse the contents of this presentation.
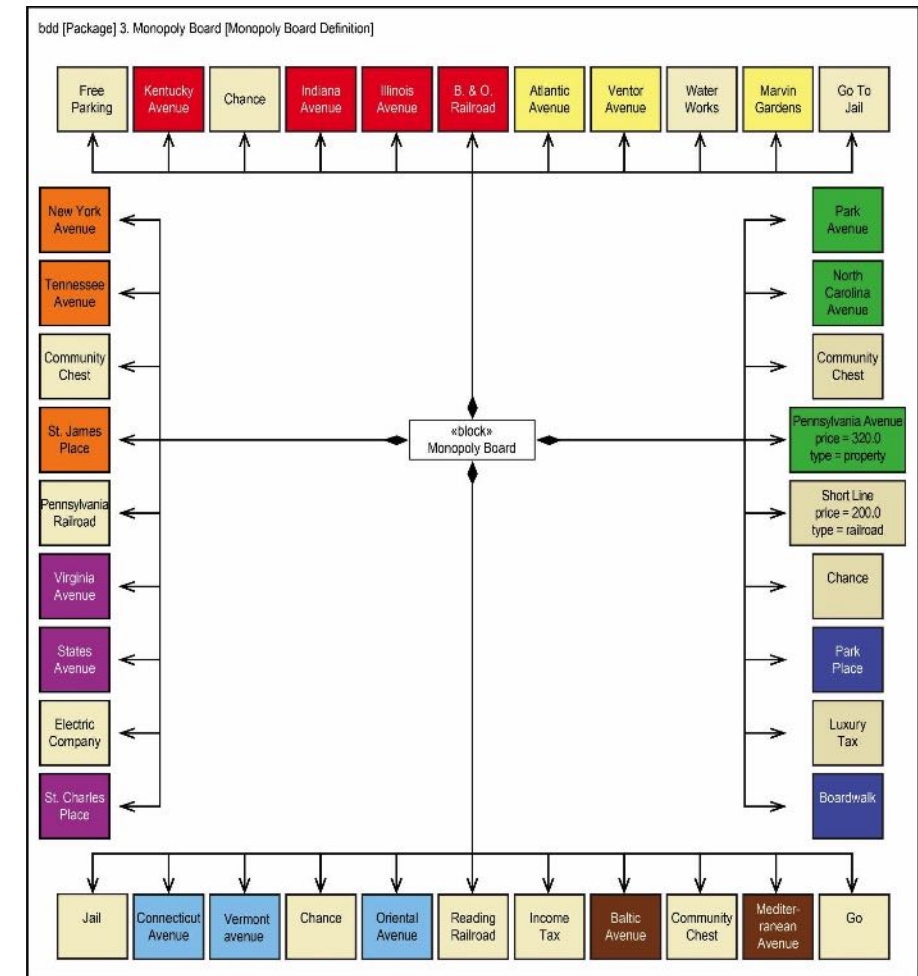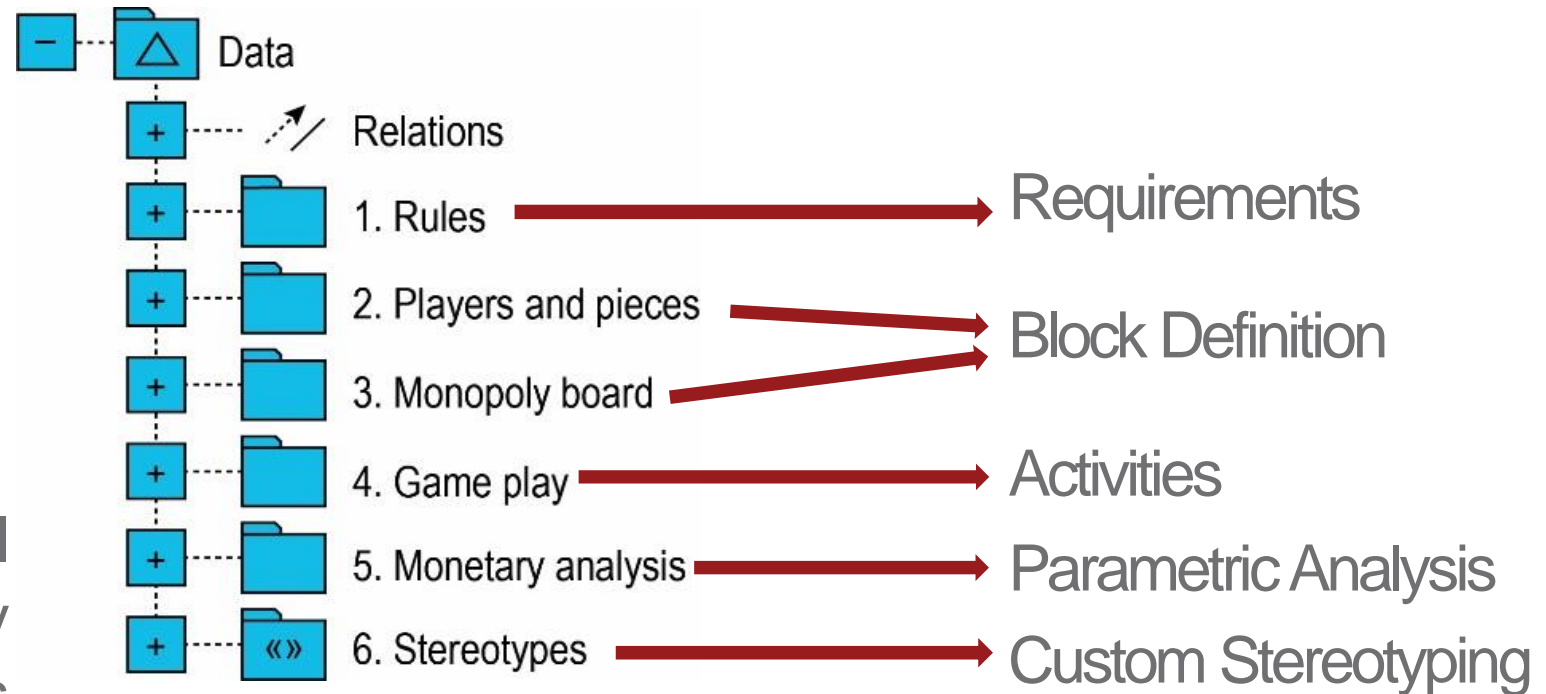
Why Monopoly?

Monopoly is highly complex: Subject is deep enough to demonstrate all aspects of SysML
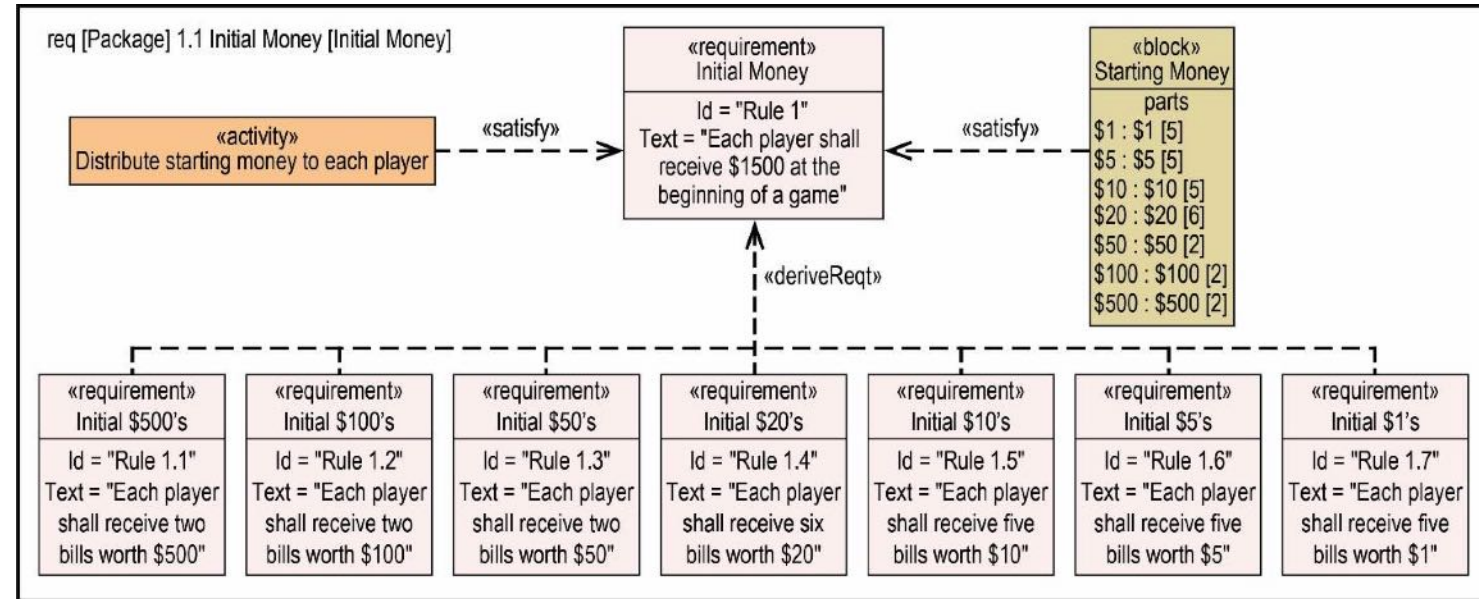
Monopoly is well understood by many people: New modelers can learn techniques using familiar content

- Data
  - Relations
  - 1. Rules → Requirements
  - 2. Players and pieces → Block Definition
  - 3. Monopoly board → Block Definition
  - 4. Game play → Activities
  - 5. Monetary analysis → Parametric Analysis
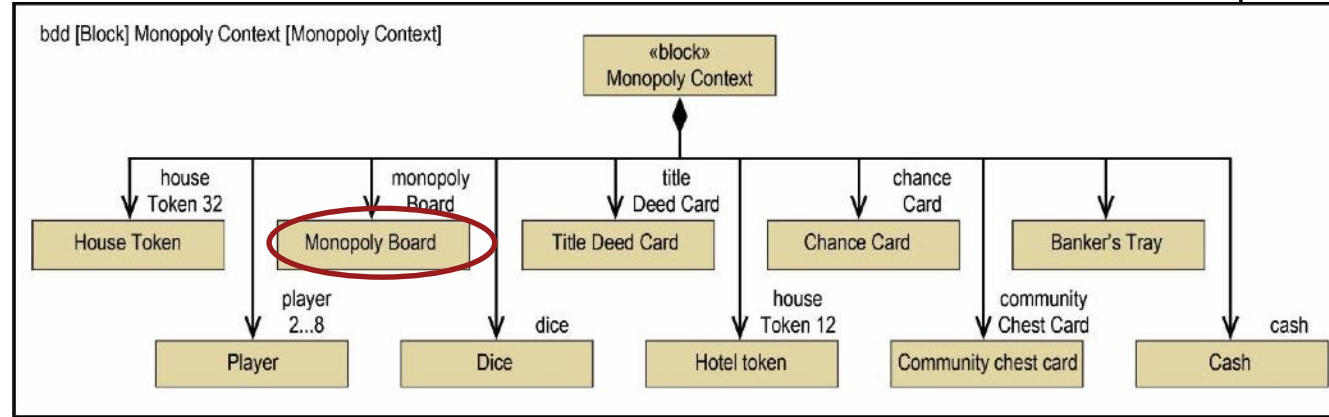 - 6. Stereotypes → Custom Stereotyping

Requirements

- Game rules modeled as requirements
- Cross-cutting modeling techniques:
  - Requirements satisfied by functions/activities
- Subtleties to explore:
  - Model game constraints as requirements
 - Evaluate alternate methods of organizing or formatting requirement models

req [Package] 1.1 Initial Money [Initial Money]

«activity»
Distribute starting money to each player

«satisfy»

«requirement»
Initial Money
Id = "Rule 1"
Text = "Each player shall receive $1500 at the beginning of a game"

«satisfy»

«block»
Starting Money
parts
$1 : $1 [5]
$5 : $5 [5]
$10 : $10 [5]
$20 : $20 [6]
$50 : $50 [2]
$100 : $100 [2]
$500 : $500 [2]

«deriveReqt»

«requirement»
Initial $500's
Id = "Rule 1.1"
Text = "Each player shall receive two bills worth $500"

«requirement»
Initial $100's
Id = "Rule 1.2"
Text = "Each player shall receive two bills worth $100"

«requirement»
Initial $50's
Id = "Rule 1.3"
Text = "Each player shall receive two bills worth $50"

«requirement»
Initial $20's
Id = "Rule 1.4"
Text = "Each player shall receive six bills worth $20"

«requirement»
Initial $10's
Id = "Rule 1.5"
Text = "Each player shall receive five bills worth $10"

«requirement»
Initial $5's
Id = "Rule 1.6"
Text = "Each player shall receive five bills worth $5"

«requirement»
Initial $1's
Id = "Rule 1.7"
Text = "Each player shall receive five bills worth $1"

Block Definition

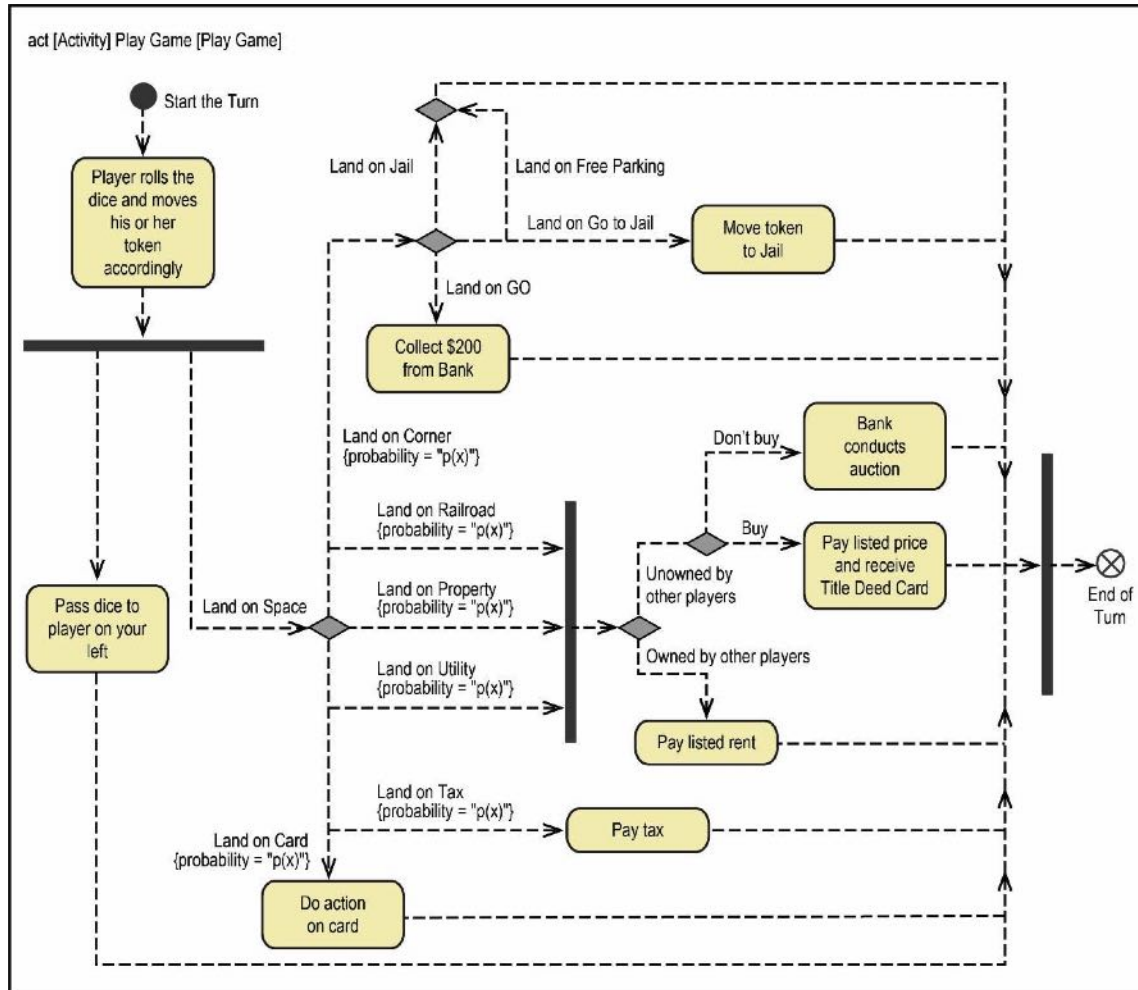bdd [Block] Monopoly Context [Monopoly Context]

- Several levels of abstraction available to the modeler
- Subtleties to explore:
  - Whether generalizations or specializations are useful to meet model objectives
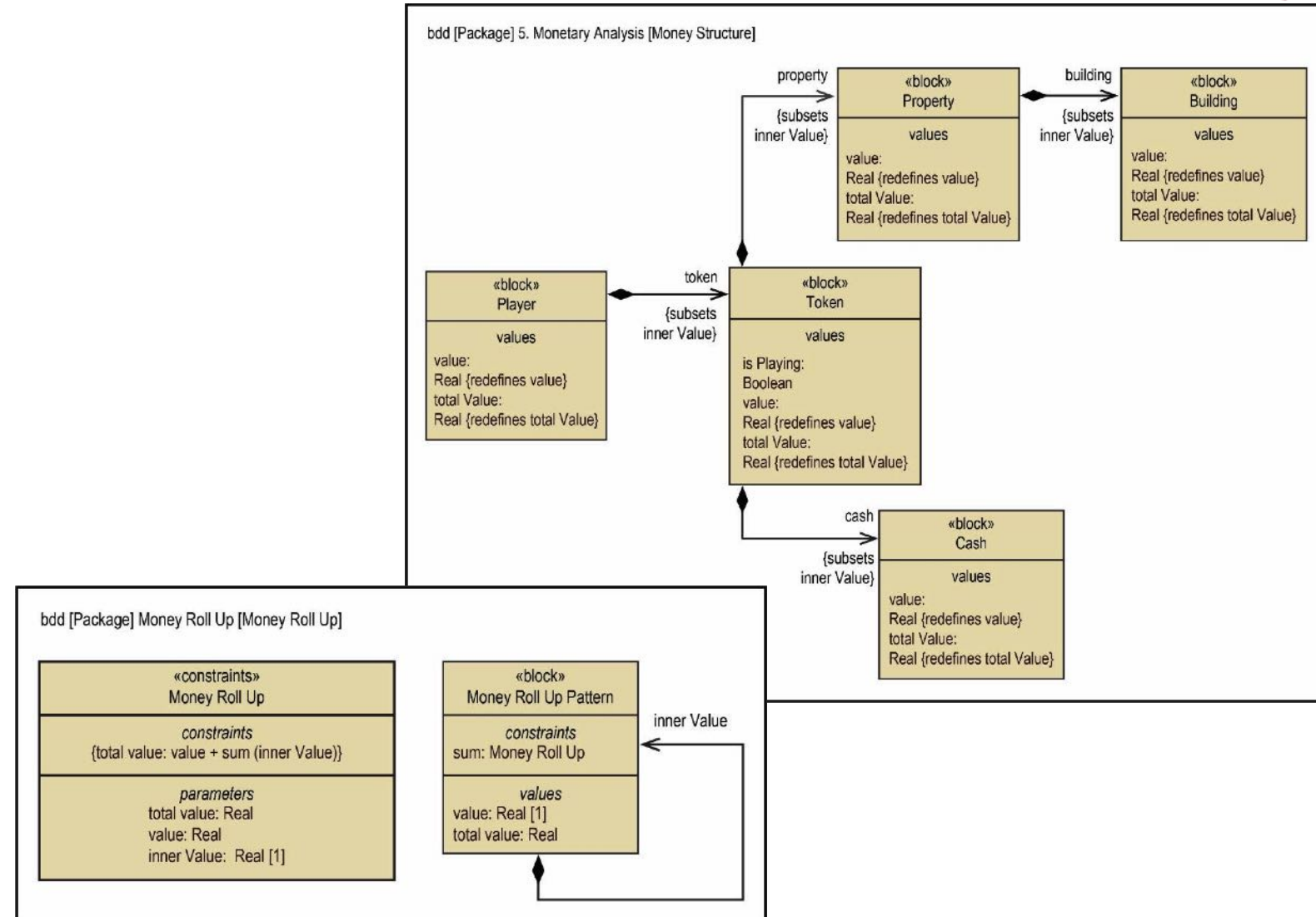 - Development of custom stereotypes
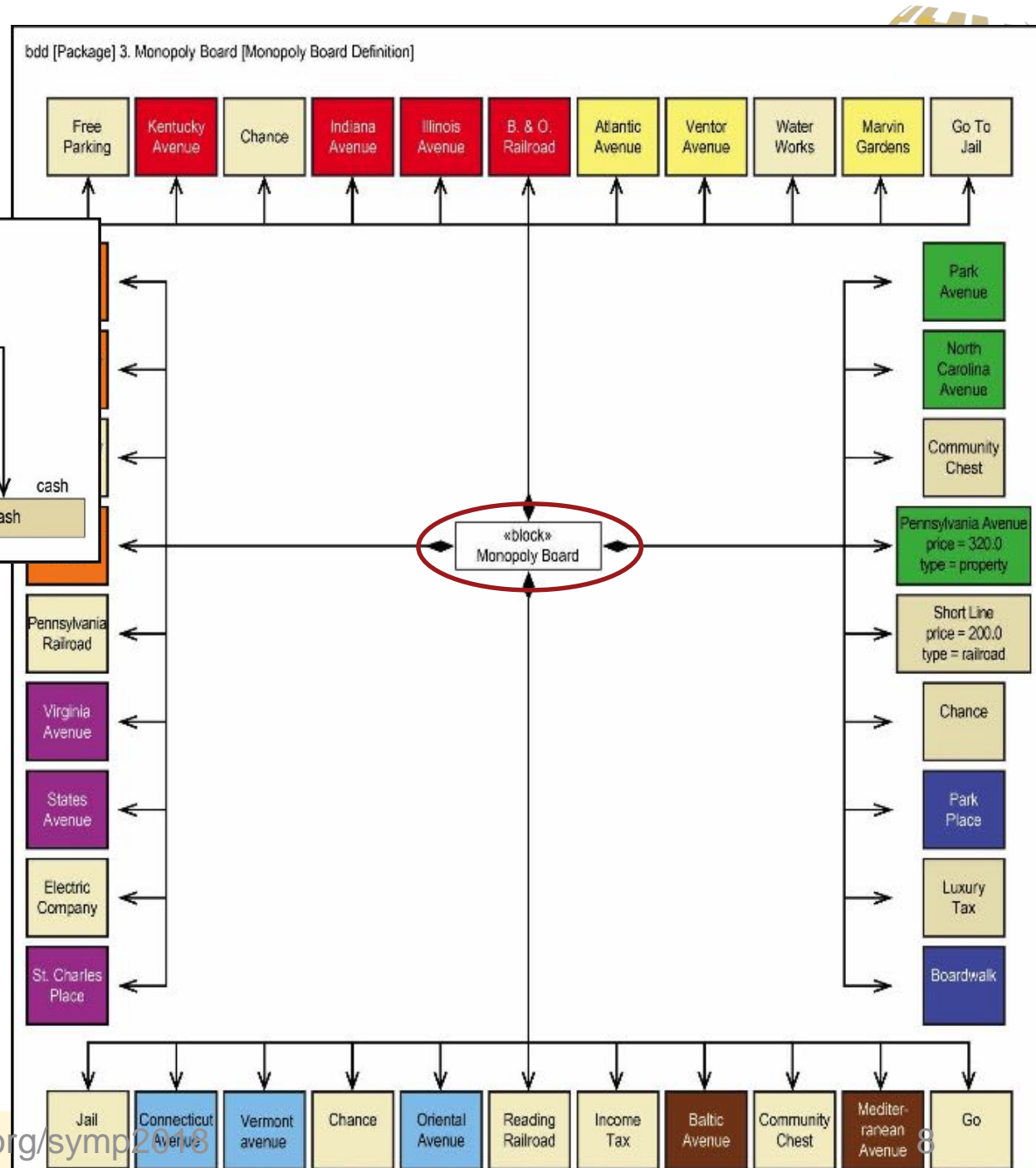
Activities

- Model the cyclical actions associated with gameplay
- Subtleties to explore:
  - Expand capabilities with object flows, swimlanes, etc.
  - Appropriate functional decomposition techniques
  - Integration with simulation and analysis

Parametrics

Money exchange and tracking

▼

Parametric modeling and analysis

Potential Future Model Content

- Use cases – Explore the different roles available among players (Banker vs. Player)

- Interfaces – Flow of money to/from Bank and players, between players; order of board spaces

- State Machines – Both technical and "social" states

- Sequences – Capture the exchanges between players and the bank requesting money or bidding on properties

Limitations and Possible Mitigations

- Iterative nature of system design is difficult to overlay on a game
  - Configuration management principles hard to introduce
  - Lifecycle processes
  - <u>Possible mitigation</u>: model games with 'legacy features' – each play permanently modifies the board or rules of the game
- Limited need for learners to strategically define and manage model scope, depth, and organization
  - <u>Possible mitigation</u>: provide teams with a "purpose prompt" which advises them to model for a specific use (simulation vs. description, e.g.)
- Time spent learning with game subject matter is time not spent learning a relevant subject matter

Testing the Hypothesis

Feasibility Assessment

Feasibility Assessment Summary

- Six participants from NASA Glenn Research Center
  - Various levels of MBSE experience
- Requested pairs of participants create a behavior model using activities and related elements to describe Monopoly
- Brought the pairs together to discuss their work as a group and provide feedback on the exercise and premise
- Participants characterized their familiarity with activity modeling before and after the sample task

Feasibility Assessment Results

Participants cited the ease of understanding the subject matter and its potential to be described in varying levels of detail

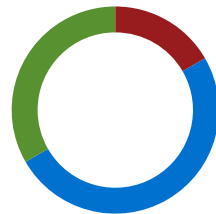Average number of SysML courses taken previously

2.3

83%

Percentage of participants reporting an increase in confidence in modeling behaviors

Prior SysML Experience:
None
Novice Practitioner
Seasoned Practitioner

4.25/5

Average likelihood to recommend the hypothesis for further study

Conclusion: The hypothesis should be more formally investigated

Forward Work

- Implement future modeling content
- INCOSE-sponsored demonstrations?
- Rigorous evaluation of the premise

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