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SYSTEMS AT THE CROSSROADS
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INCOSE

GLRC 2018

Applying System Modeling to Wargame and Boardgame Design

Why Boardgames?

Boardgames are a multi-billion dollar market!

- $9.4 Billion (2016 global sales)
- 24% growth in UK market
- $1.4 Billion (2016 U.S. sales)
- Traditional publishers plus Kickstarter

Local Game Stores and Mass-Market

- Mass-market retailers (Target, Meijer, and others) stock a growing number of modern boardgames.
- Barnes & Noble has grown its games section.

The FLGS: Friendly Local Game Store

Games and Mechanics

What Is A Game?

- "A series of interesting choices."
  – Sid Meier, designer of *Civilization* and *Pirates!*

- A framework of rules and conditions agreed upon by the players.

- Engages the players' dopamine cycle - Decision, Anticipation, Resolution.

Board Games: Roll-and-Move

- Egyptian Senet (3100 B.C.)
- Monopoly®
- Trouble®
- Et al.

  Limited decision opportunities

https://games.talkingpyramids.com/wp-content/uploads/PaperSenetWhite.jpg

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Playing Cards

- Invented in 9th Century China
- Spread to Europe in the 14th Century
- Professional printed (woodcuts) in 15th Century
- Suits became standardized
- Allowed the creation of the games we know:
  - Cribbage
  - Poker
  - Hearts
  - Spades
  - Euchre
  - Et al.

Board Games: Eurogames

Eurogames (or alternatively, Designer Board Games or German-Style Board Games) are a classification of board games that are very popular on Board Game Geek (BGG). Though not all eurogames are European and not all of them are board games, they share a set of similar characteristics. A game need not fit ALL the criteria to be considered a Eurogame.

Selected Eurogame Elements

- Player conflict is indirect and usually involves competition over resources or points. Combat is extremely rare.
- Players are never eliminated from the game.
- There is very little randomness or luck. Randomness that is there is mitigated by having the player decide what to do after a random event happens rather than before. Dice are rare, but not unheard of, in a Euro.
- Much attention is paid to the artwork and components. Plastic and metal are rare, more often pieces are made of wood.
- Eurogames have a definite theme, however, the theme most often has very little to do with the gameplay. The focus instead is on the mechanics; for example, a game about space may play the same as a game about ancient Rome.

Eurogames

- Settlers of Catan®
- Power Grid®
- Carcassone®

  More opportunities and critical thinking

Board Games: Ameritrash

Ameritrash is "a catchphrase for 'American style boardgames.' In general, this means games that emphasize a highly developed theme, characters, heroes, or factions with individually defined abilities, player to player conflict, and usually feature a moderate to high level of luck."

Ameritrash

- War of the Ring®
- Star Wars: Rebellion®
- Battlestar Galactica®
- Twilight Imperium®
- A Touch of Evil®
- Fortune and Glory®
- Eldritch Horror®

https://boardgamegeek.com/image/1735714/eldritch-horror

Other Game Mechanics

- Area control
- Cubes/items from bags (random draw)
  - *Thebes* (2007) (dirt on archaeological digs)
  - *1960: The Making of the President* (2007)
- Worker Placement
  - *Fresco* (2010)
  - *Lords of Waterdeep* (2012)

Wargames

- Miniatures (H.G. Wells's *Little Wars*)
- Hex-and-Counter (Charles S. Roberts)
  - *Tactics* (1954)
  - *Gettysburg* (1958)
- Squares (later hexes)
- Counters
- Combat Results Table

https://playingintheworldgame.files.wordpress.com/2013/06/pic593269.jpg?w=538&h=385

Block Wargames

- Created by Gamma Two Games (later Columbia)
- Creates "fog of war" with hidden, variable-strength units
  - *Hammer of the Scots*
  - *Athens & Sparta*
  - *Quebec 1759*

https://cf.geekdo-images.com/imagepage/img/ymCtQm_9Z21uf2v8jjTrSauZ1q4=/fit-in/900x600/filters:no_upscale()/pic694717.jpg

Card-Driven Wargames

- Popularly credited to Mark Herman
  - *We the People* (1994)
- Network of nodes and links replaced the hex map
- Cards to active units/create events
- Lower unit density
- Simplified dice rolling

- …all combine to speed play (all the "fun" decisions remain, with less drag/overhead/friction and bookkeeping)
- Spawned a new genre and revitalized wargaming

We the People

Cards
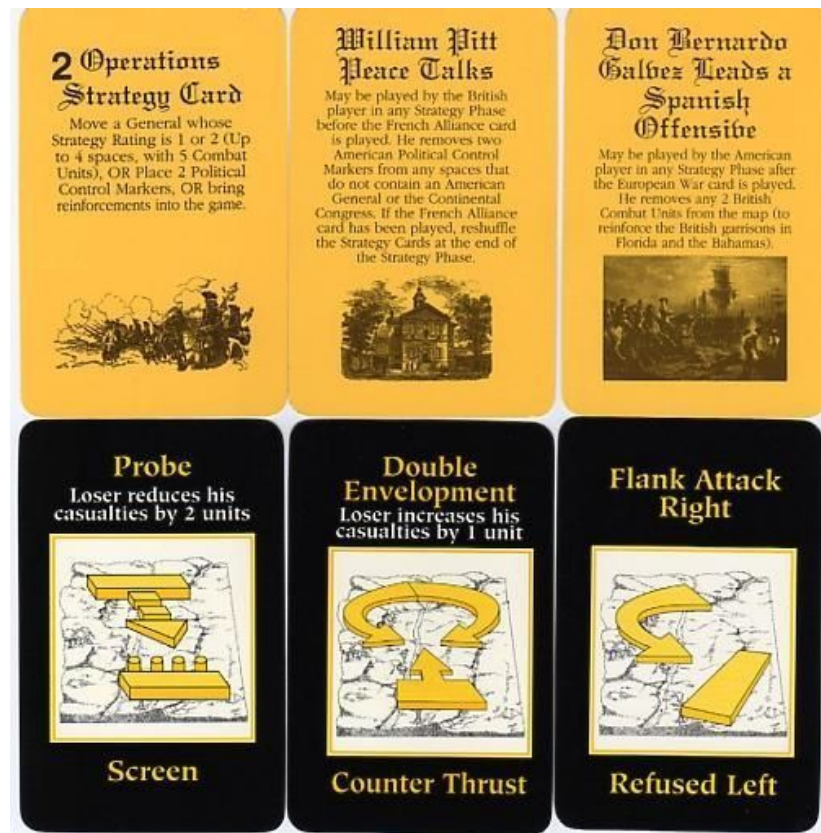
Board and Generals

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So What?

- So all games, despite their theme and chosen mechanics, have commonalities:
  - One wins by satisfying victory conditions
  - Rules are executed by humans (they are the OS!)
  - Balance and consistency are important
  - Playtesting/debugging can be lengthy
  - Errors damage company reputation/increase costs
- System modeling can help!

Q.E.D.

- What is the *Question* we need to answer?
- How can we *Extract* relevant information from the model?
- How should we *Display* it to stakeholders in a meaningful, easy to consume way?

See Tim Weilkiens's *Query-Driven Modeling* for similar concepts.

Tak: Initial Analysis

Tak: A Beautiful Game

- Mentioned in Patrick Rothfuss's *The Wise Man's Fear*

- Developed into a game by Rothfuss and James Ernest

https://cheapass.com/tak/
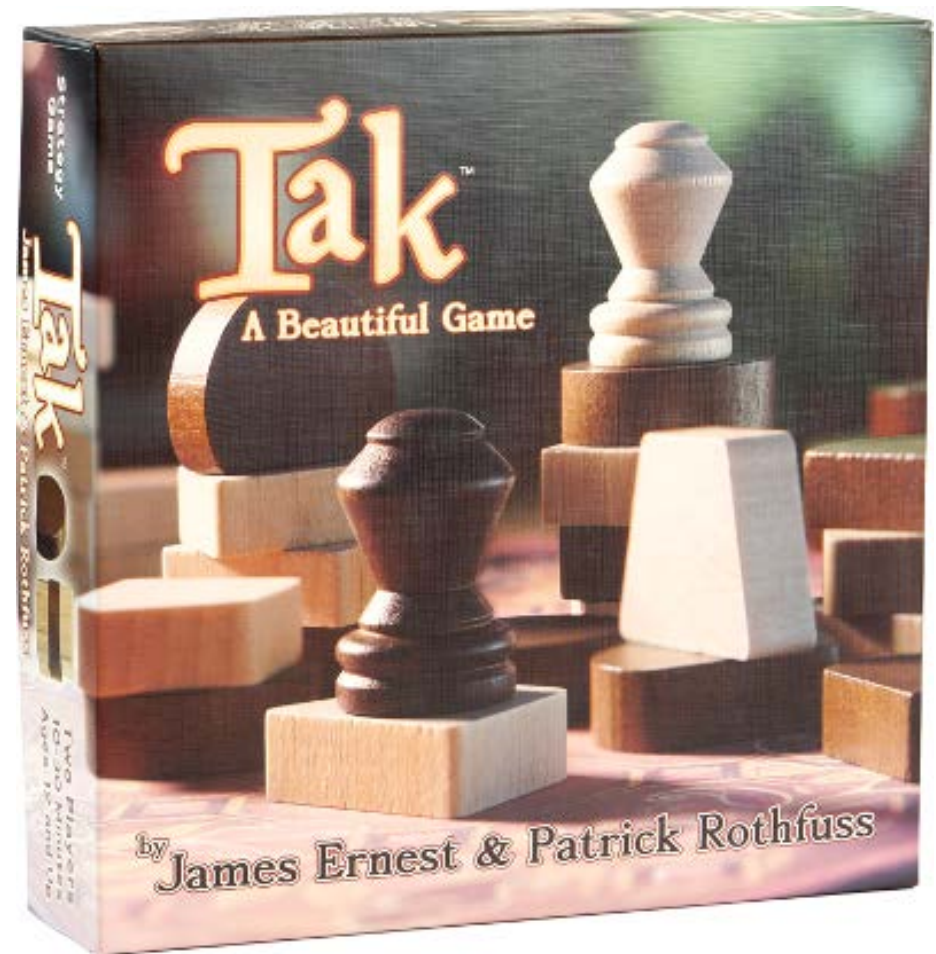
Tak

- Simple rules
- The *go* of this fantasy world

- …so it was a challenge for the developers to create a game with that feel.

Tak: Components

- 1 Board (equal number of rows and columns)
- "Stones"
- Capstones

https://cf.geekdo-images.com/imagepage/img/XeHTbce2IsWj-5FIgpKoGfhVpCg=/fit-in/900x600/filters:no_upscale()/pic3775956.jpg

Variant Modeling

4x4 Game

#	△ Name	Multiplicity
1	[P] black Capstone	0
2	[P] black Piece	15
3	[P] black Player	1
4	[P] board	1
5	[P] white Capstone	0
6	[P] white Piece	15
7	[P] white Player	1

8x8 Game

#	△ Name	Multiplicity
1	[P] black Capstone	2
2	[P] black Piece	50
3	[P] black Player	1
4	[P] board	1
5	[P] white Capstone	2
6	[P] white Piece	50
7	[P] white Player	1

Tak Player Functions

#	Name	Constraints
1	○ Move Controlled Stack	{} Stack Control=Top Stone is Player's Color
2	○ Place Capstone	{} Placement Restriction=On Empty Space
3	○ Place Flat Stone	{} Placement Restriction=On Empty Space
4	○ Place Standing Stone	{} Placement Restriction=On Empty Space

Player State Machine

- Captures possible moves for a given turn
- Illustrates game end conditions that lead to victory checks on the game state machine

Player State Machine

stm [State Machine] Player [Player]

Turn Start

[Place Capstone?] / Place Capstone

[Place Standing Stone?] / Place Standing Stone

Move Stack() [Move Stack?] / Move Stack

Place Flat Stone() [Place Flat Stone?] / Place Flat Stone

[Victory Conditions Unsatisfied]

[Road(s) Completed]

[No Empty Spaces Remain]

Turn Complete

Road Victory

Flats Victory
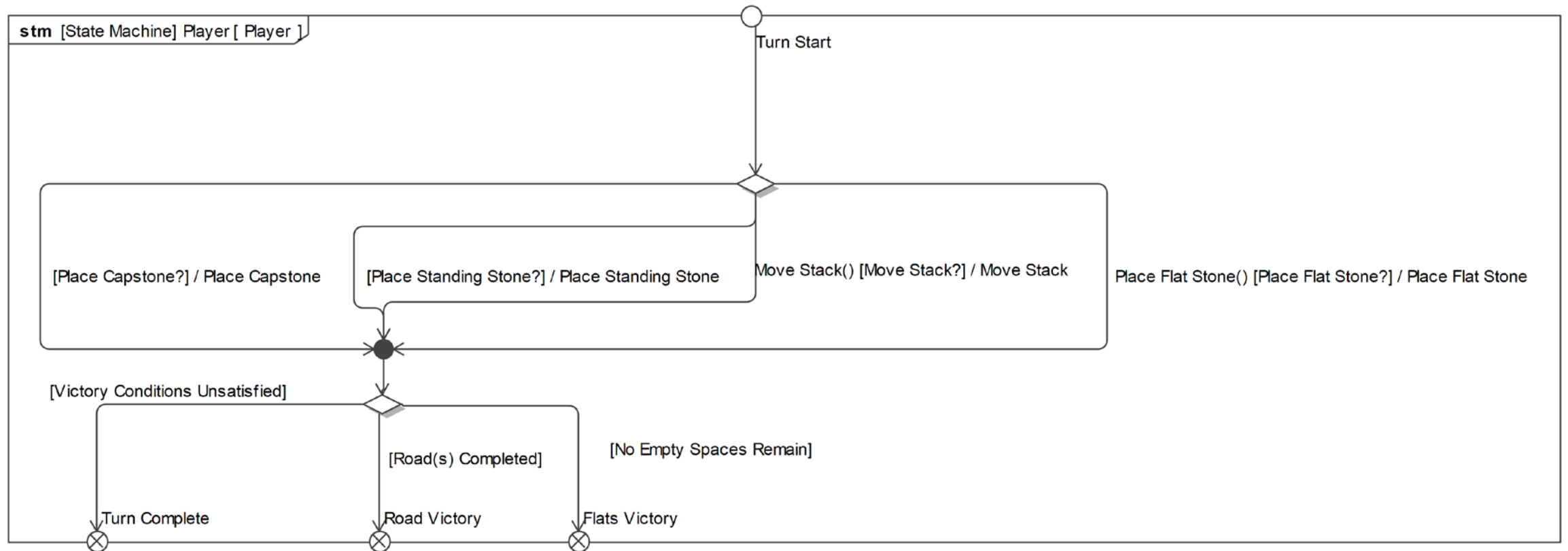
Move Stack Activity Diagram

- Captures the limitations imposed by standing stones and capstones
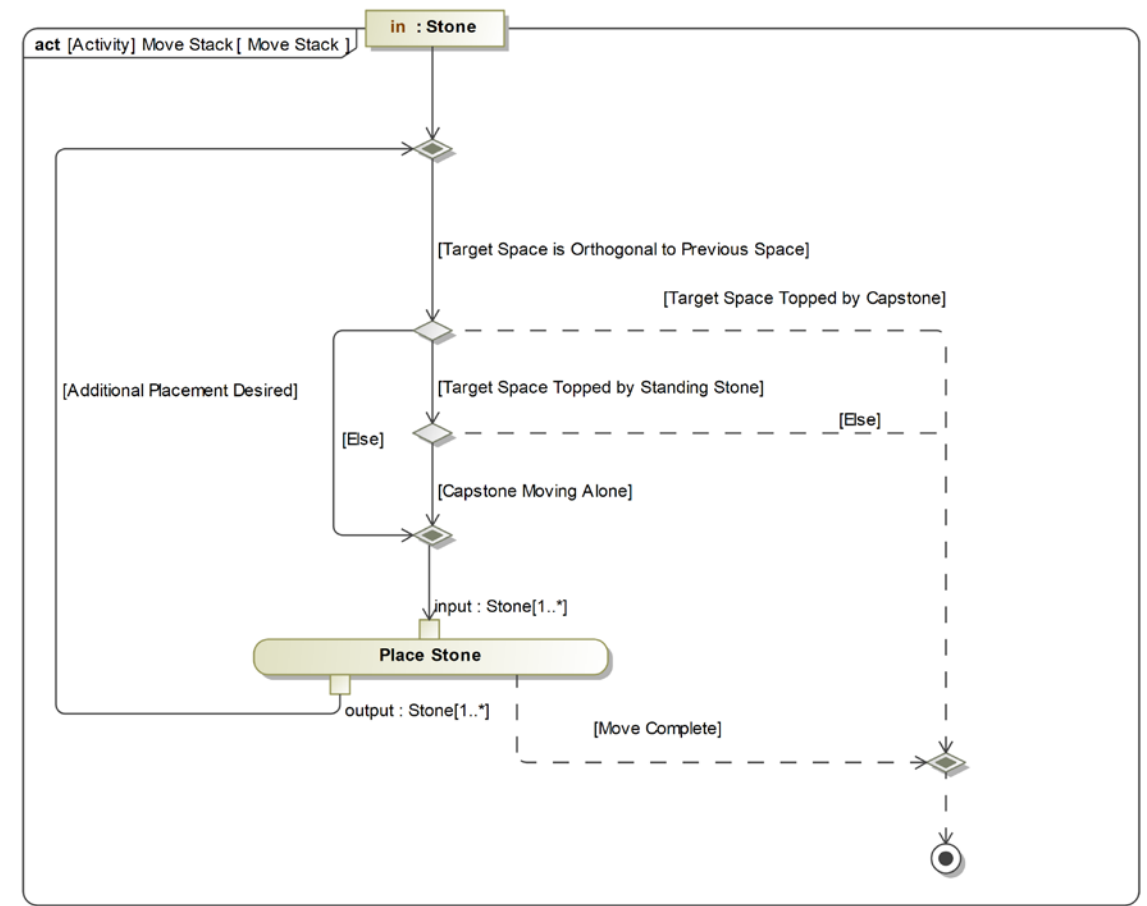
Stone State Machine

- Captures states and transitions for stones
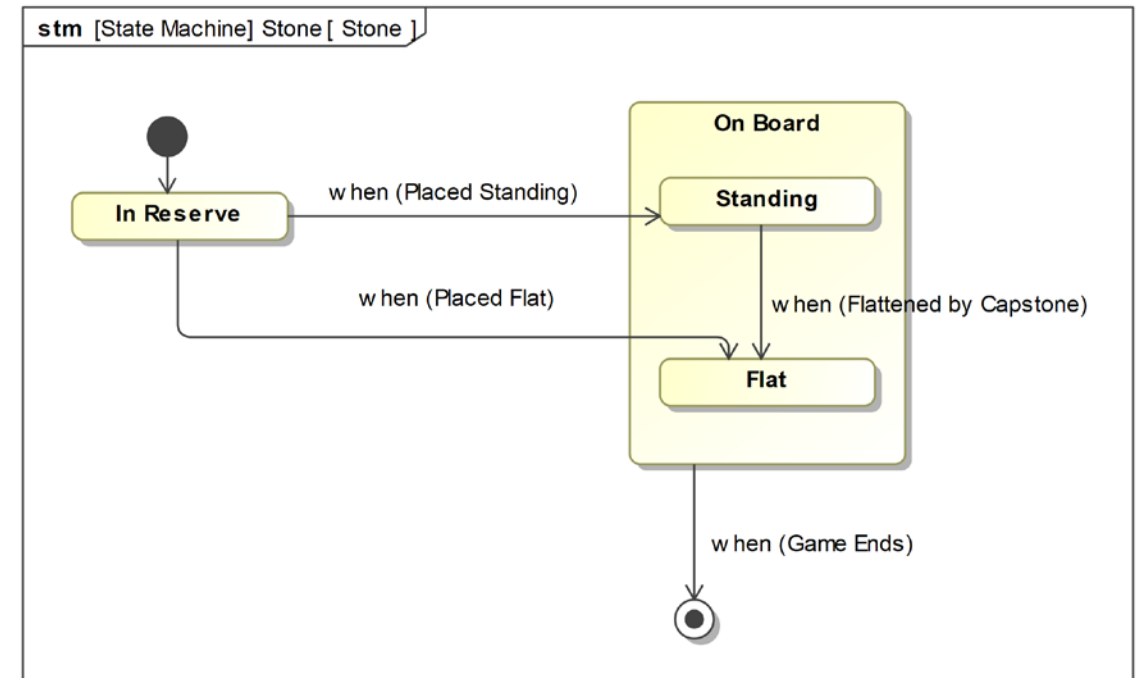
Game State Machine

- Modeling game states makes turns and victory conditions clear

- Guards and constraints can be further analyzed
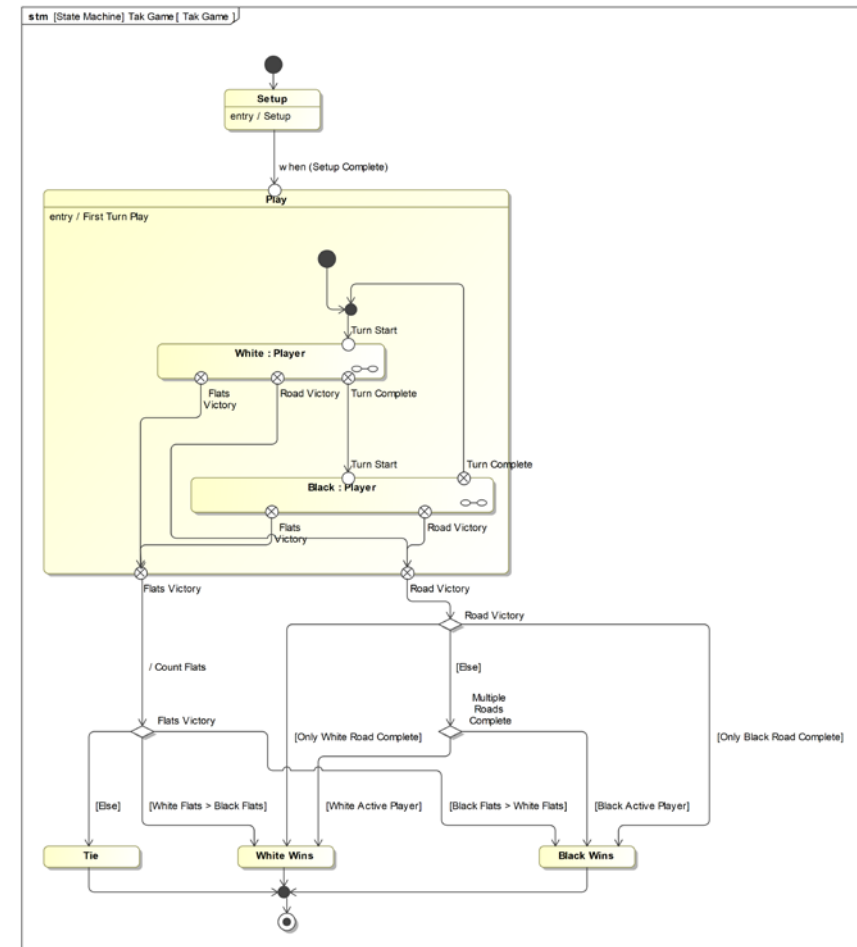
First Turn Play
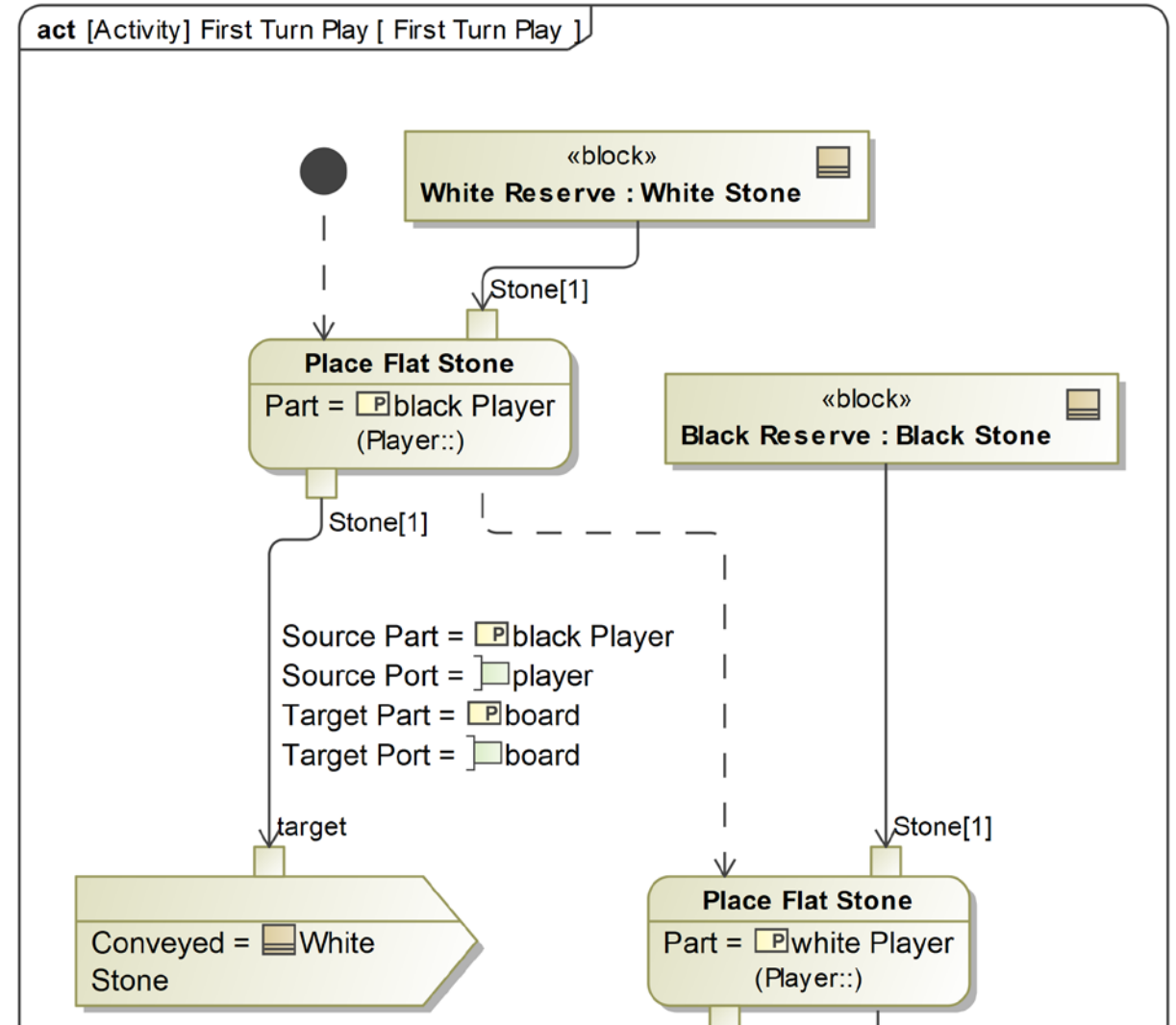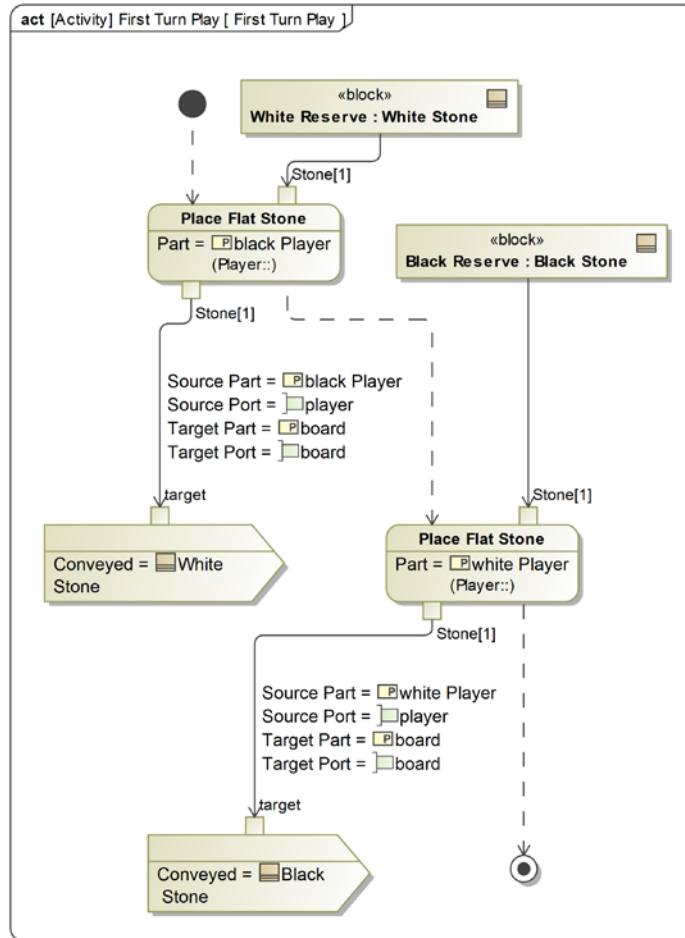
Place Flat Stone / Capstone
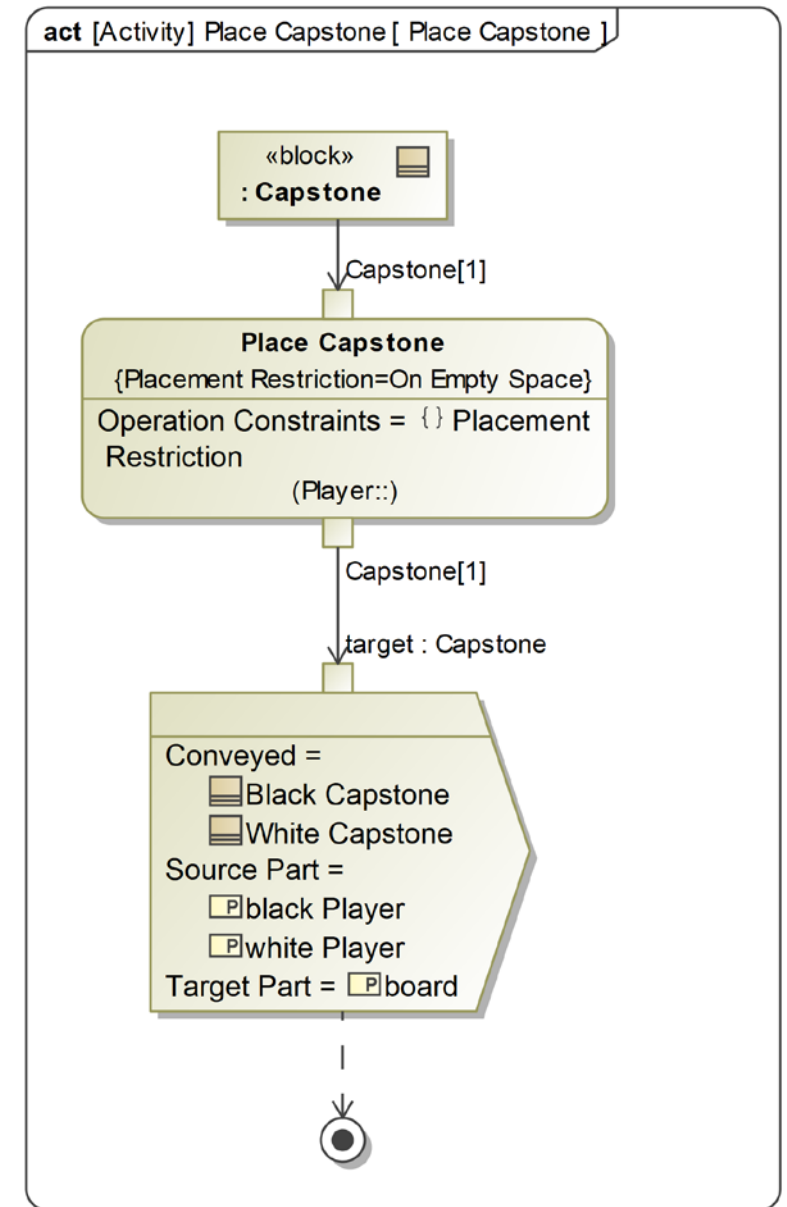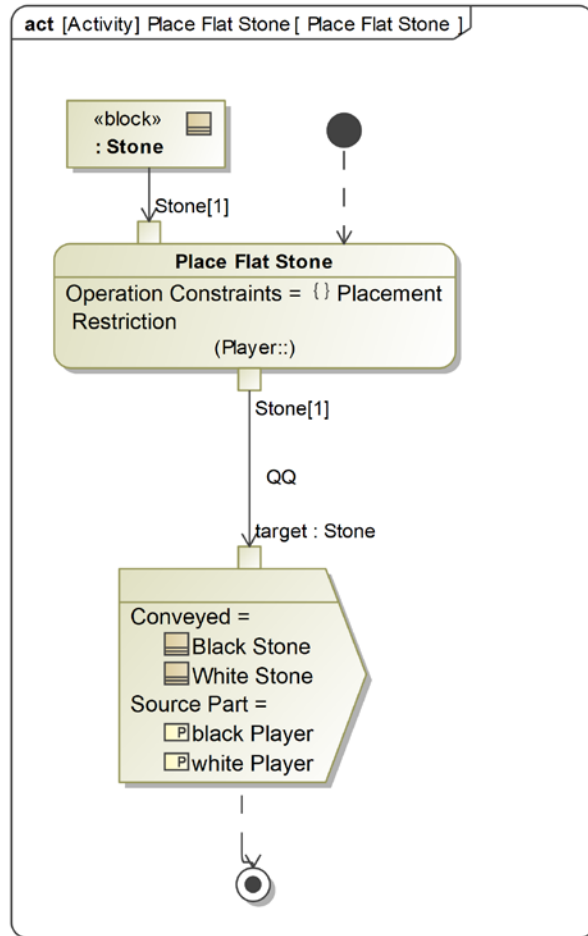
Play State Detail

- Note the reuse of the Player state machines
- Two victory conditions allow exit: Flats Victory and Road Victory
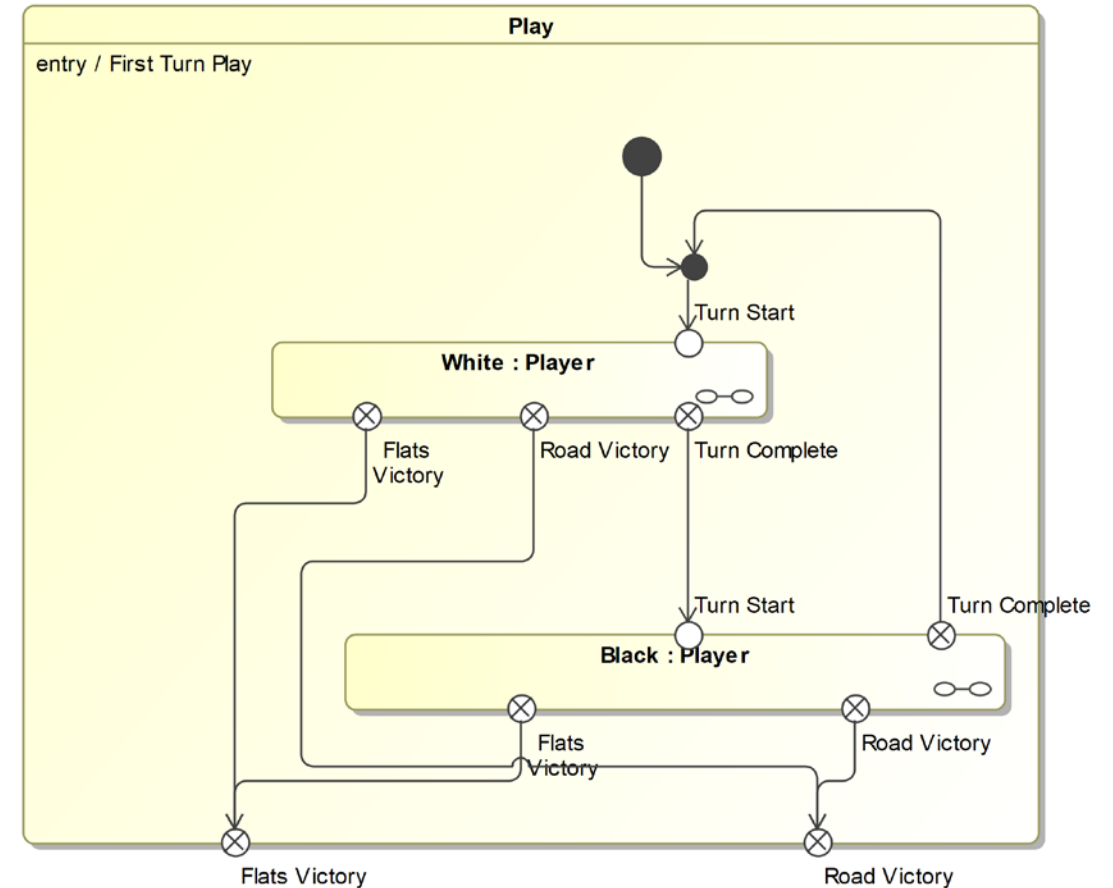
Victory Conditions

#	△ Victory Type	Choice	Guard	Winner
1	⊗ Flats Victory	◇ Flats Victory	Black Flats > White Flats	▭ Black Wins
2	⊗ Flats Victory	◇ Flats Victory	White Flats > Black Flats	▭ White Wins
3	⊗ Flats Victory	◇ Flats Victory	Else	▭ Tie
4	⊗ Road Victory	◇ Multiple Roads Complete	Black Active Player	▭ Black Wins
5	⊗ Road Victory	◇ Road Victory	Only Black Road Complete	▭ Black Wins
6	⊗ Road Victory	◇ Road Victory	Only White Road Complete	▭ White Wins
7	⊗ Road Victory	◇ Multiple Roads Complete	White Active Player	▭ White Wins

Wargame Analysis

1812: The Invasion of Canada

- *1812: The Invasion of Canada* is a card-driven wargame from Academy Games

- It uses cards, dice, and a draw bag of turn order markers to regulate game flow.

- Weight: rated 2.17/5 (medium-light) by www.boardgamegeek.com

The Game

<<iconholder>>

- MagicDraw stereotype applied to an enumeration

- Automatically applies icon when parent stereotype tag is set
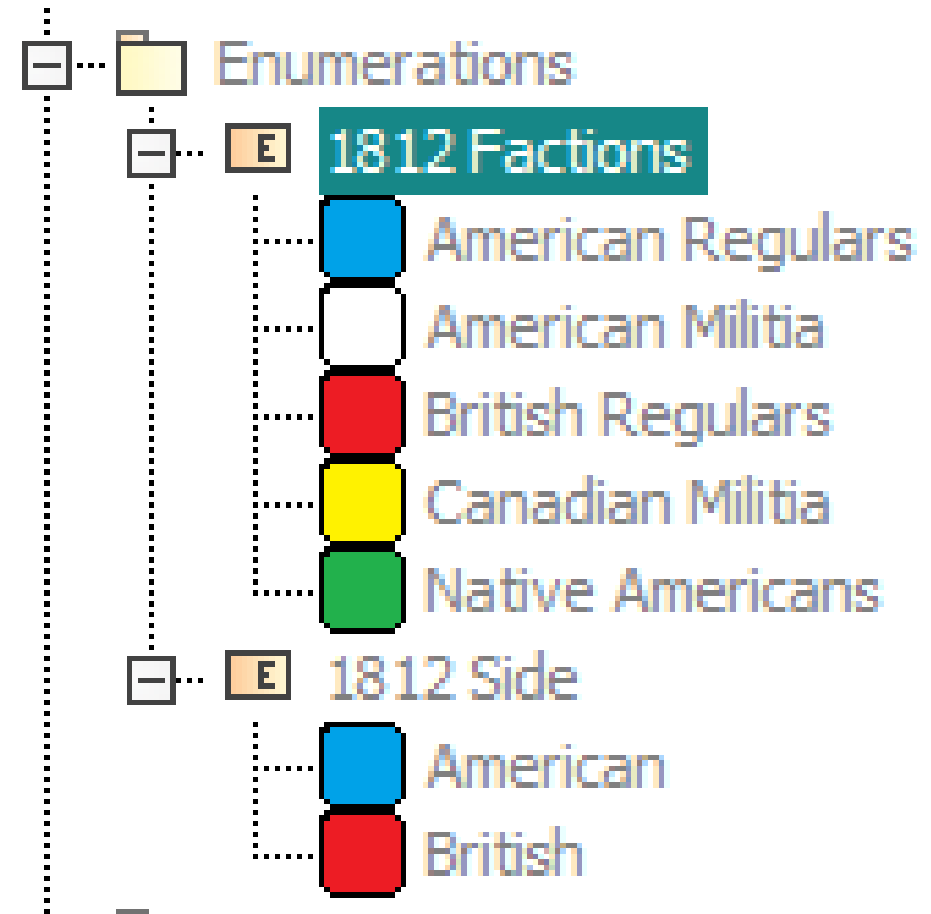
Homeland Areas

#	Name	Side	Starting Units	Muster	Objective Value
1	P albany	🟦 American	P : American Regulars [1] P : American Militia [1]	P : American Regulars [1] P : American Militia [1]	1
2	P amerherstburg	🟥 British	P : British Regulars [1] P : Canadian Militia [1]		1
3	P American Empty 1	🟦 American			0
4	P American Empty 2	🟦 American			0

Muster Areas

#	△ Owner	Type	Multiplicity
1	Albany	American Militia	1
2	Albany	American Regulars	1
3	Montreal	British Regulars	1
4	Montreal	Canadian Militia	1
5	Pittsburgh	American Militia	2
6	Pittsburgh	American Regulars	2
7	Six Nations	Native American	1
8	Six Nations	Native American	1
9	York	British Regulars	1
10	York	Canadian Militia	1

Starting Units

#	△ Owner	Type	Multiplici
1	🟦 Albany	⬜ American Militia	1
2	🟦 Albany	🟦 American Regulars	1
3	🟥 Amerherstburg	🟥 British Regulars	1
4	🟥 Amerherstburg	🟨 Canadian Militia	1
5	🟦 Buffalo	⬜ American Militia	4
6	🟦 Buffalo	🟦 American Regulars	1
7	🟦 Caldwell	⬜ American Militia	1

Map
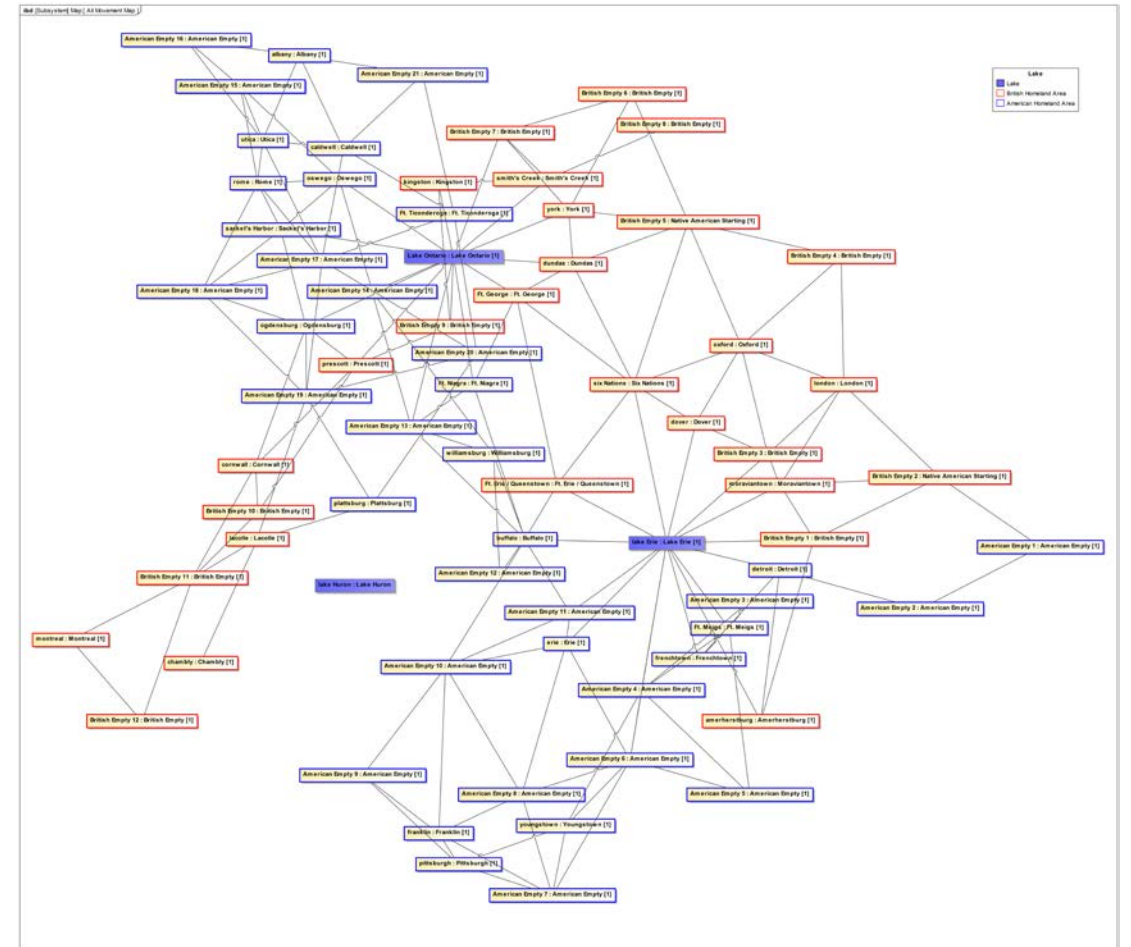
Dynamic Legend

Map Key (by vinarcmi)
- Lake (by vinarcmi)
- British Homeland Area (by v...
- American Homeland Area (t...
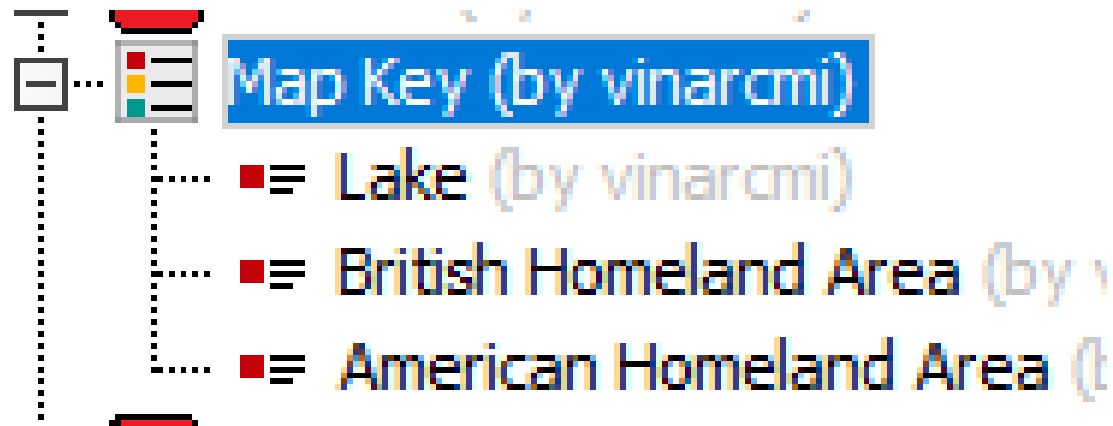
Body:

Condition
  Property Test(Side=British)
    Element = Metachain Navigation
    Properties =
    Regular Expression = false
    Case Sensitive = false
    Match Anywhere = true
    AND Operator = true
  Create operation...

Property Test::Element   Edit   Use as...   Reset

Operation Name: Metachain Navigation1

Metaclass or Stereotype	Property
PartProperty [Property]	Type

Insert

Remove

Water and Direct Connections
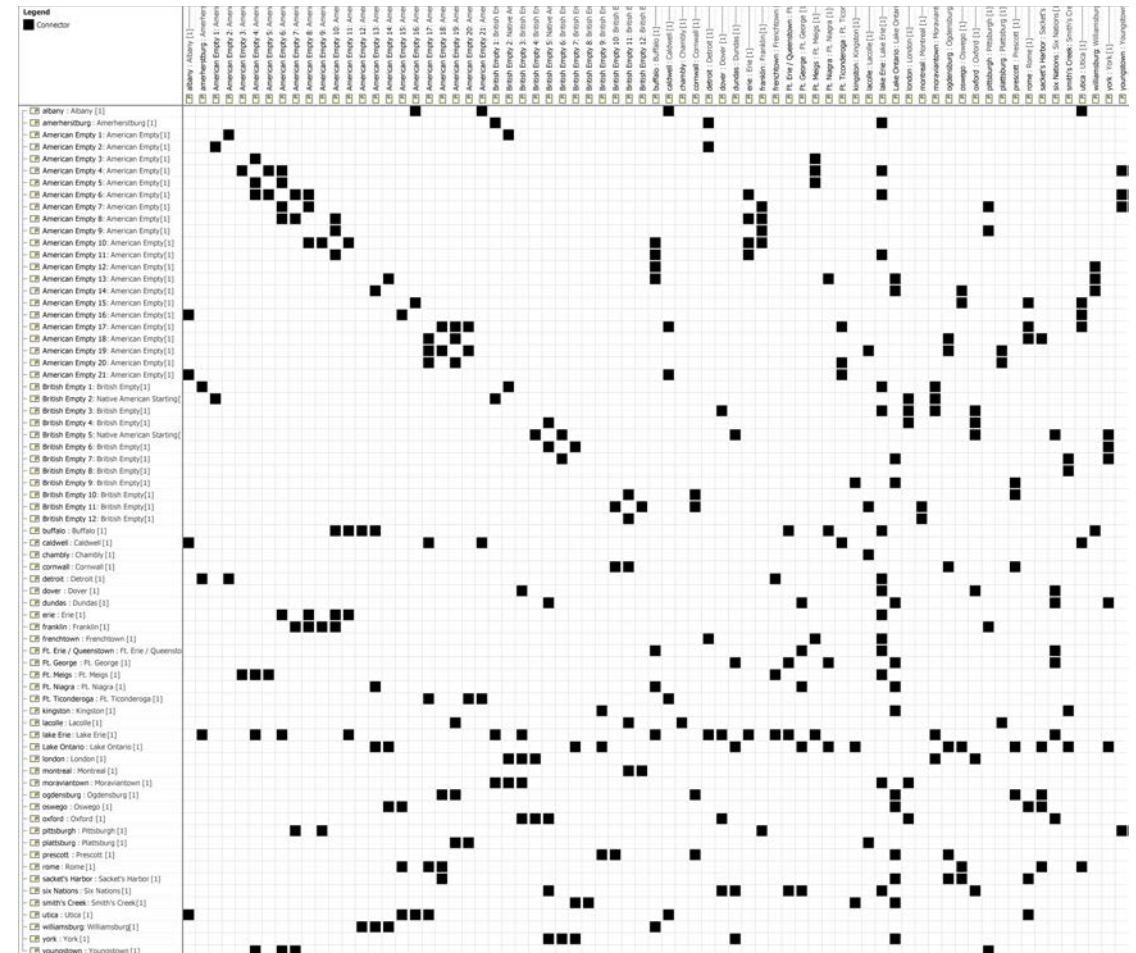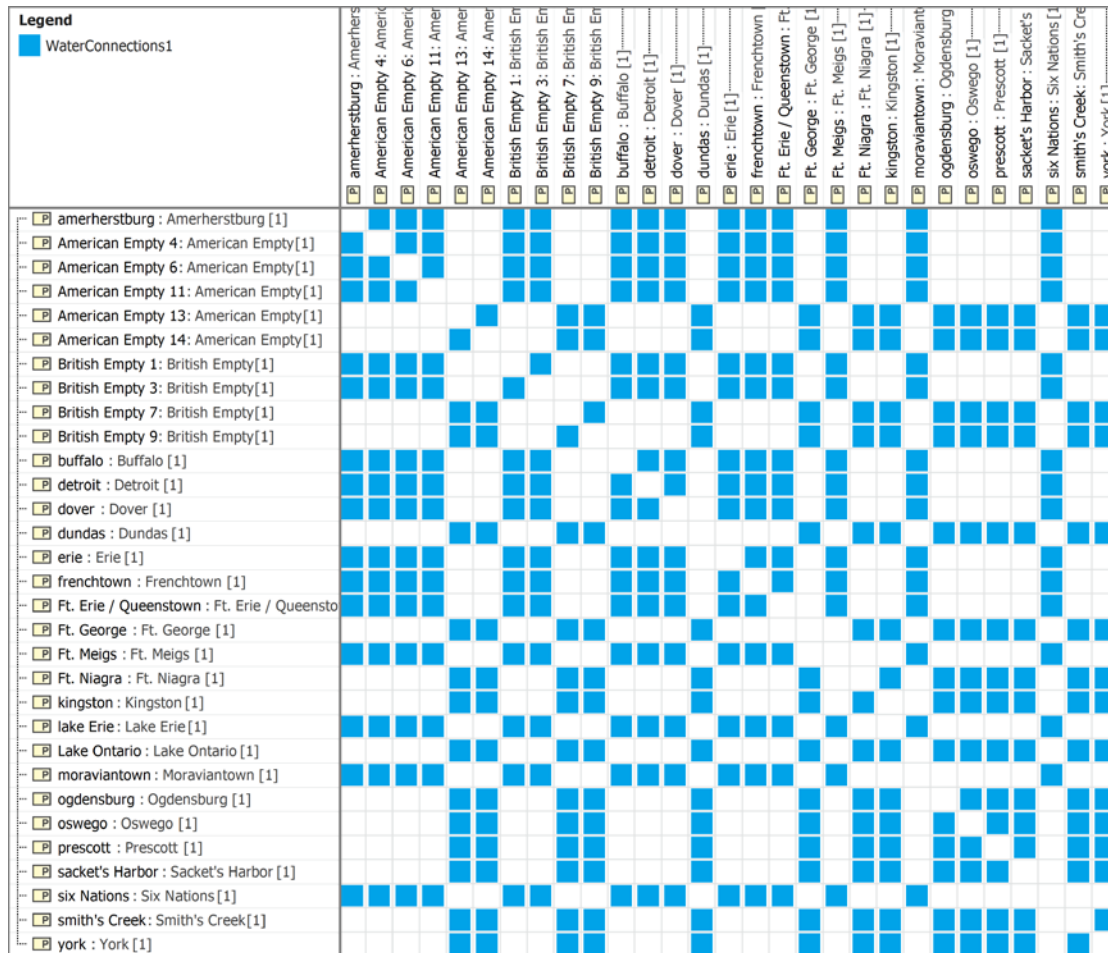
Map Reachability

- Color coded based distanced between map areas (1-3 land moves or one water move away)
- Allows analysis of vulnerabilities and play balance
- Also available in a table
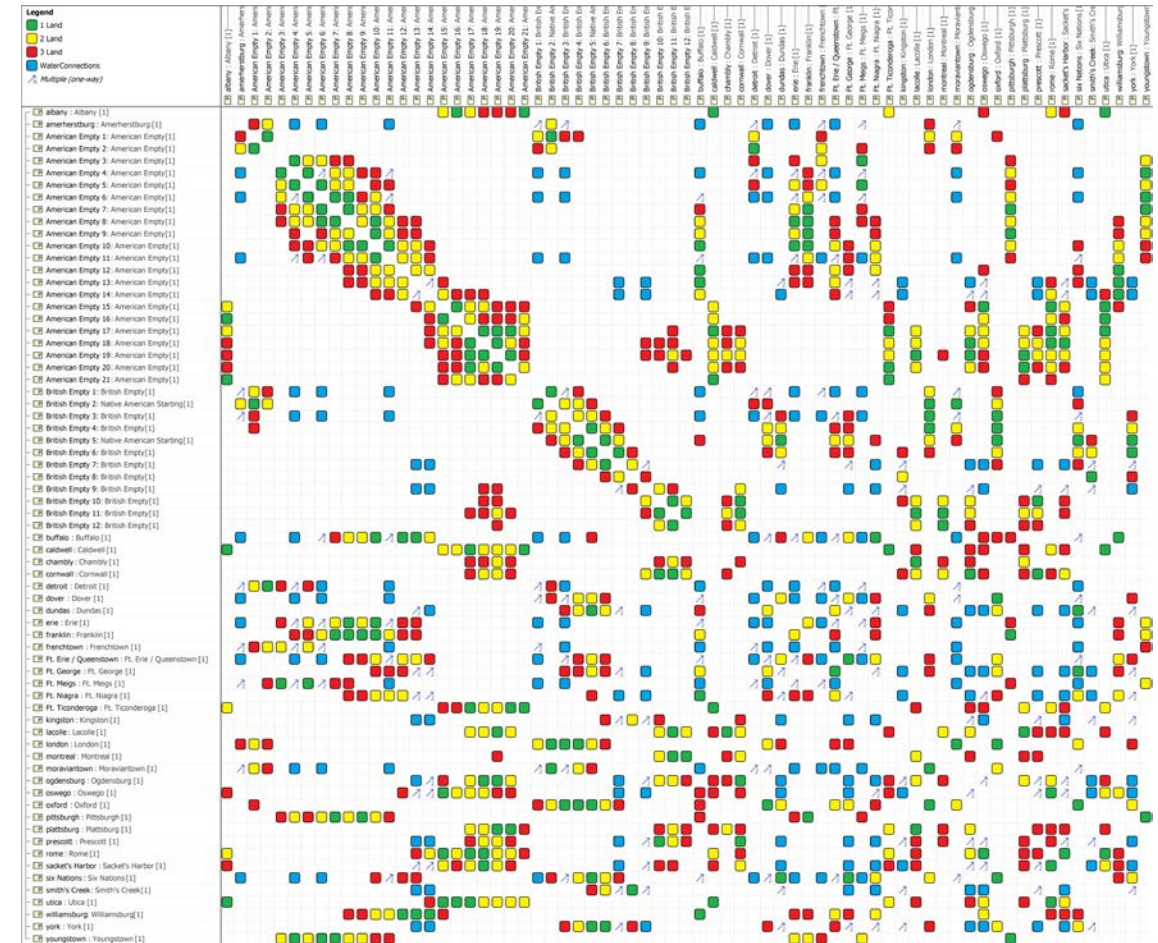
Dice

#	Type	Multipl	Hit Sides	Flee Sides	Command Decision Sides
1	⬜ American Militia Die	3	2	2	2
2	🟦 American Regulars Die	2	3	1	2
3	🟥 British Regulars Die	2	3	0	3
4	🟨 Canadian Militia Die	3	2	2	2
5	🟩 Native Americans Die	3	2	1	3

Cards

Cards As Modeled

#	Nu	Name	Title	Faction	Armies Moved	Areas Moved	Special Action	General
1	1	☐ American Militia-01	Movement	American Militia	2	3		⊠ Movement
2	2	☐ American Militia-02	Movement	American Militia	2	3		⊠ Movement
3	3	☐ American Militia-03	Movement	American Militia	3	2		⊠ Movement
4	4	☐ American Militia-04	Movement	American Militia	3	2		⊠ Movement
5	5	☐ American Militia-05	Movement	American Militia	4	1		⊠ Movement
6	6	☐ American Militia-06	Truce	American Militia	4	2	Sign the Treaty of Ghent	⊠ Movement
7	7	☐ American Militia-07	Fishing Boat Movement	American Militia	2			⊠ Movement
8	8	☐ American Militia-08	Fishing Boat Movement	American Militia	2			⊠ Movement
9	9	☐ American Militia-09	Kentucky Militia	American Militia			All American Militia hit results inflict 2 hits in all battles this turr	⊠ Special
10	10	☐ American Militia-10	Hometown Support	American Militia			Add 2 American Militia units to one American Homeland Objecti	⊠ Special
11	11	☐ American Militia-11	Captain Aisquith's Sharpshooters	American Militia			In all battles this turn, select which enemy units are removed b	⊠ Special
12	12	☐ American Militia-12	Turncoat	American Militia			Replace 1 Canadian Militia unit with 1 American Militia unit in o	⊠ Special

1812 State Machine

1812 State Machine Detail

1812 State Machine

[All Factions Have Taken A Turn] / Return Turn Order Markers to Draw Bag and Advance Round Marker

[Round 3 Complete and All Faction Truce Cards for One Side Played]

Assess Victory Conditions
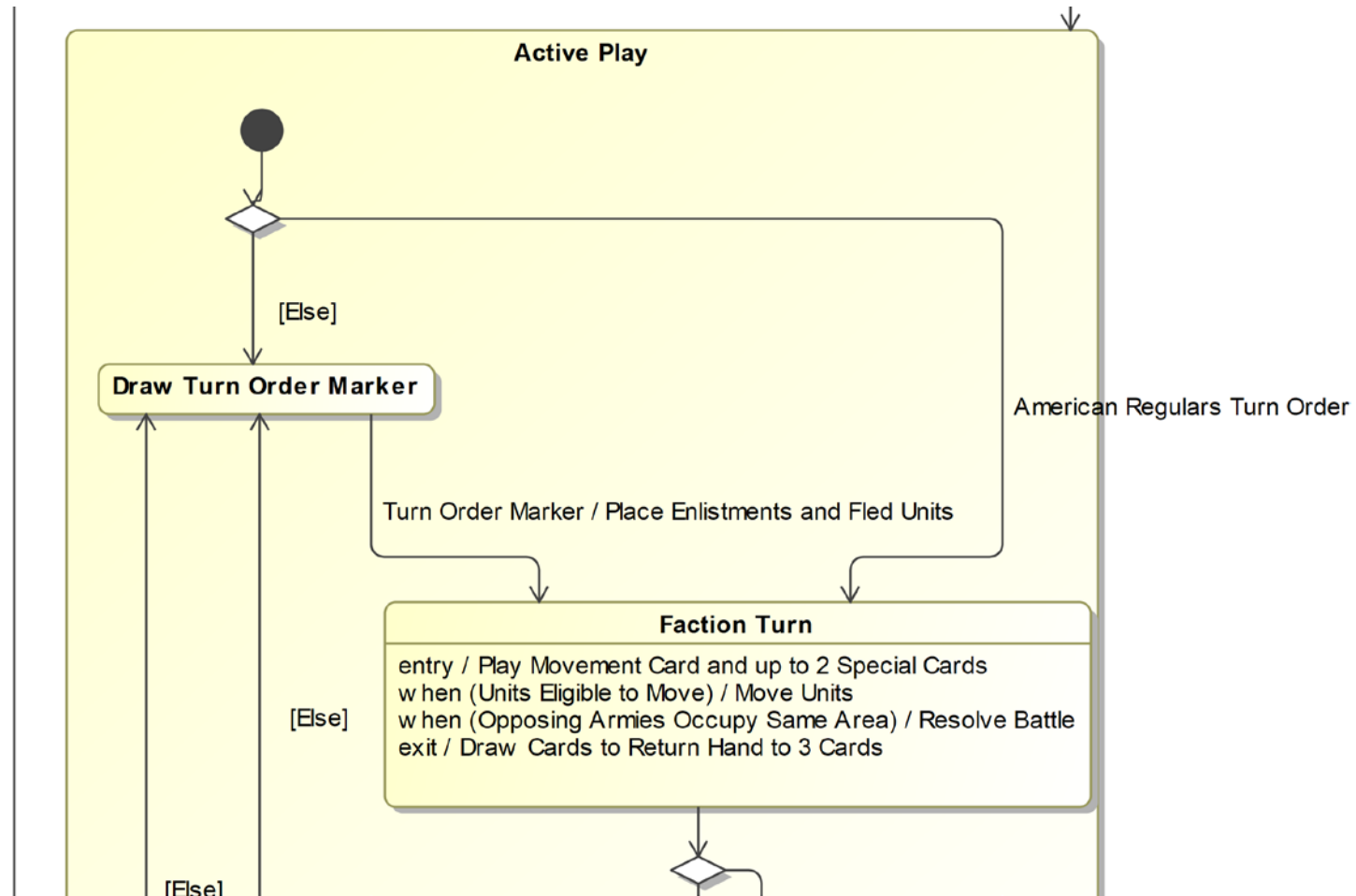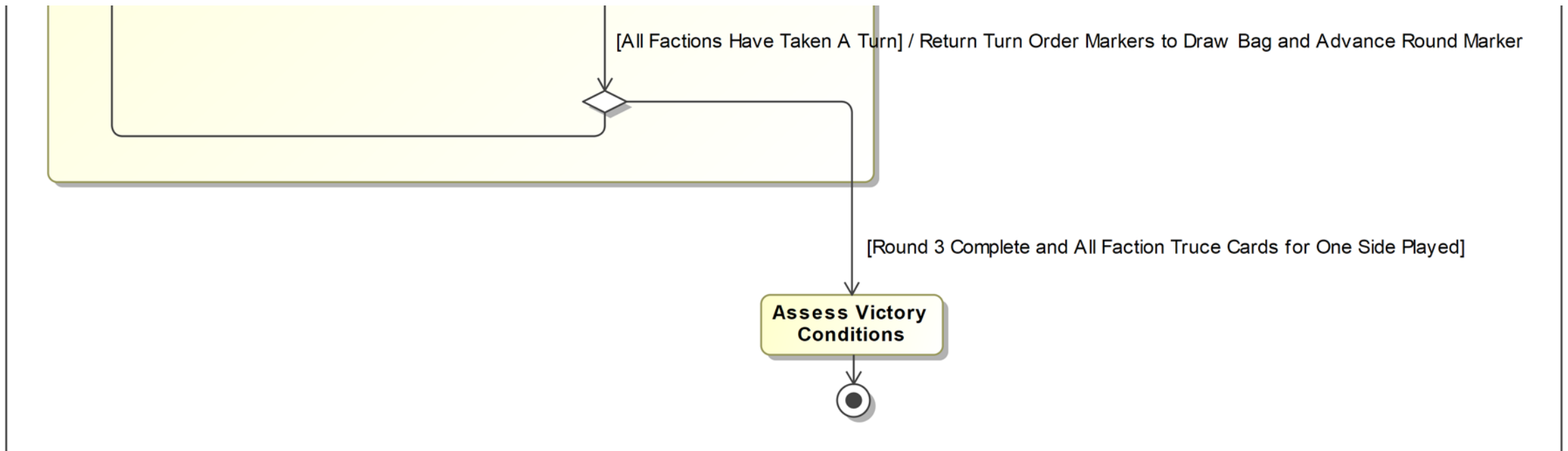
Place Enlistments and Fled Units

- Uses constraints and guards to describe rules

- Enlistments lost if area occupied by enemy
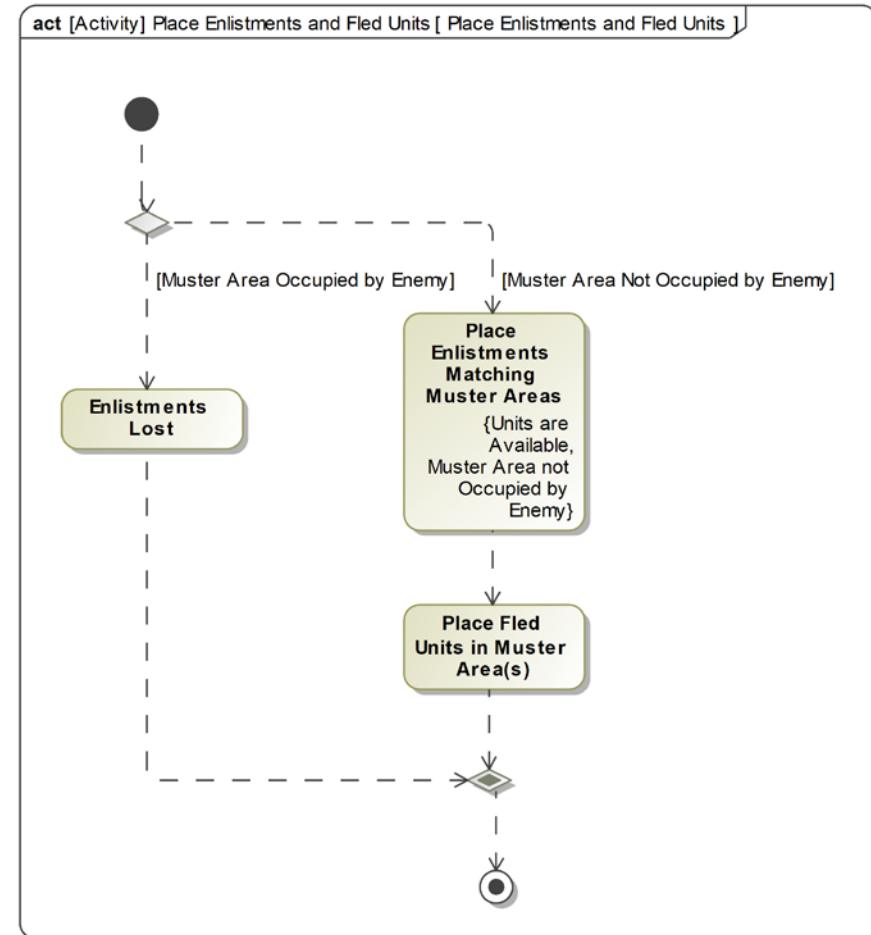
Conclusions

Conclusion

- SysML modeling can be used to model the components, interfaces, and behavior associated with boardgames.

- Modest customization was required (stereotypes/tags for relevant information).

- The rigor and clarity brought by a system model can help developers ensure the integrity and balance of their games.

Conclusion, Continued

- The application of probabilistic transitions (Markov chains) and orthogonal states will facilitate analysis of more complex card-driven games.

- Identification and elimination of "fiddly" corner cases can be completed to streamline rules and flatten the learning curve.

Conclusion, Continued

- Some games under development are campaign-driven with radiant story lines. Descriptive modeling will permit designers to visualize probable outcomes through a chain of events to find broken paths, low probability outcomes, etc.

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