Analysis of Bridges & Wormholes Paper

Part 1 – How Control Works

First Delivered: November 24, 2025

Last Updated: December 8, 2025

Michael M Lee

Introduction

Purpose of Analysis Effort

- Understand the wormhole approach to bridging
- Assess its viability
- Provide an overview of the approach that makes it more accessible
- Identify possible improvements

Key Terms

- Home (requesting service) domain
- Away (providing service) domain
- MX = Model Execution/Software Architecture domain

Major Concepts in B&W Paper

Pre-existing Concepts (Bridge Services in Away)

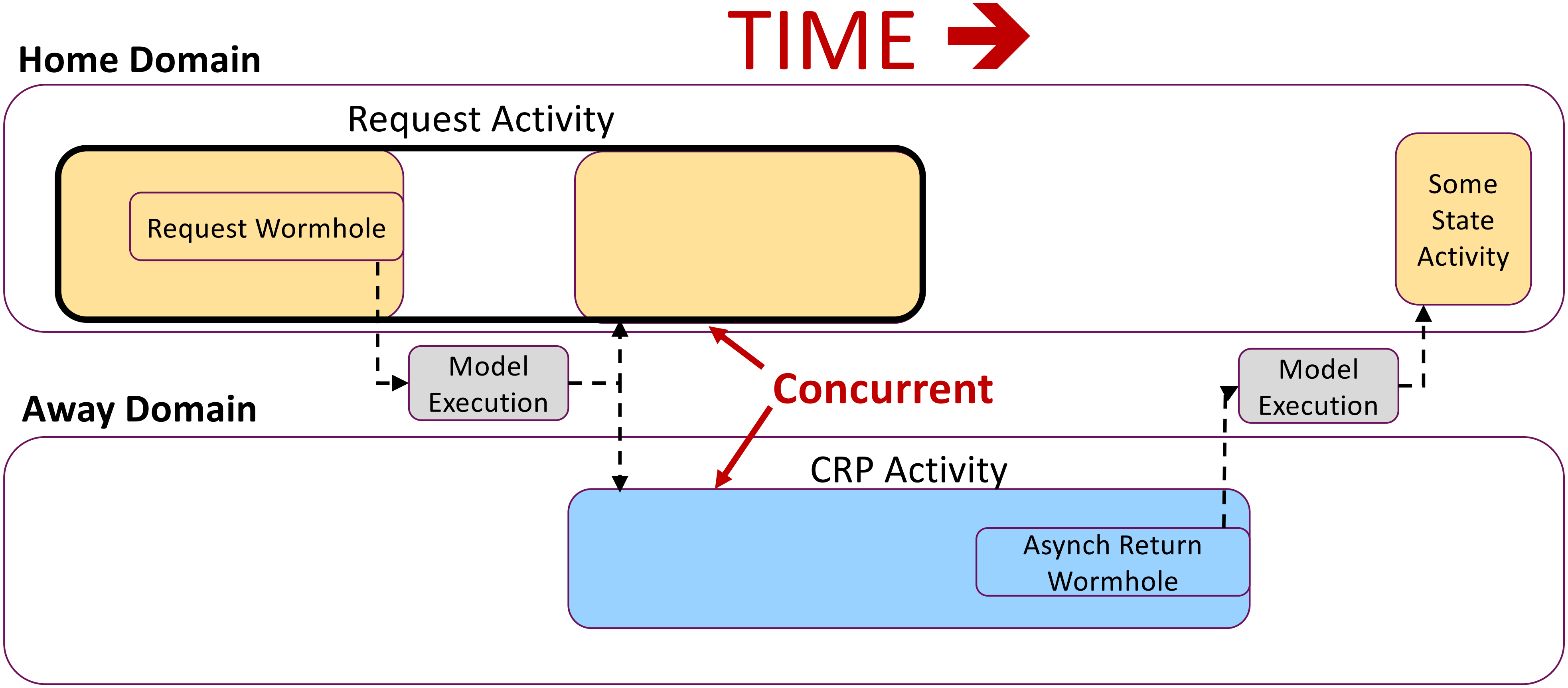
- **External Event**
- **Synchronous Service**

Control Reception Point (CRP)

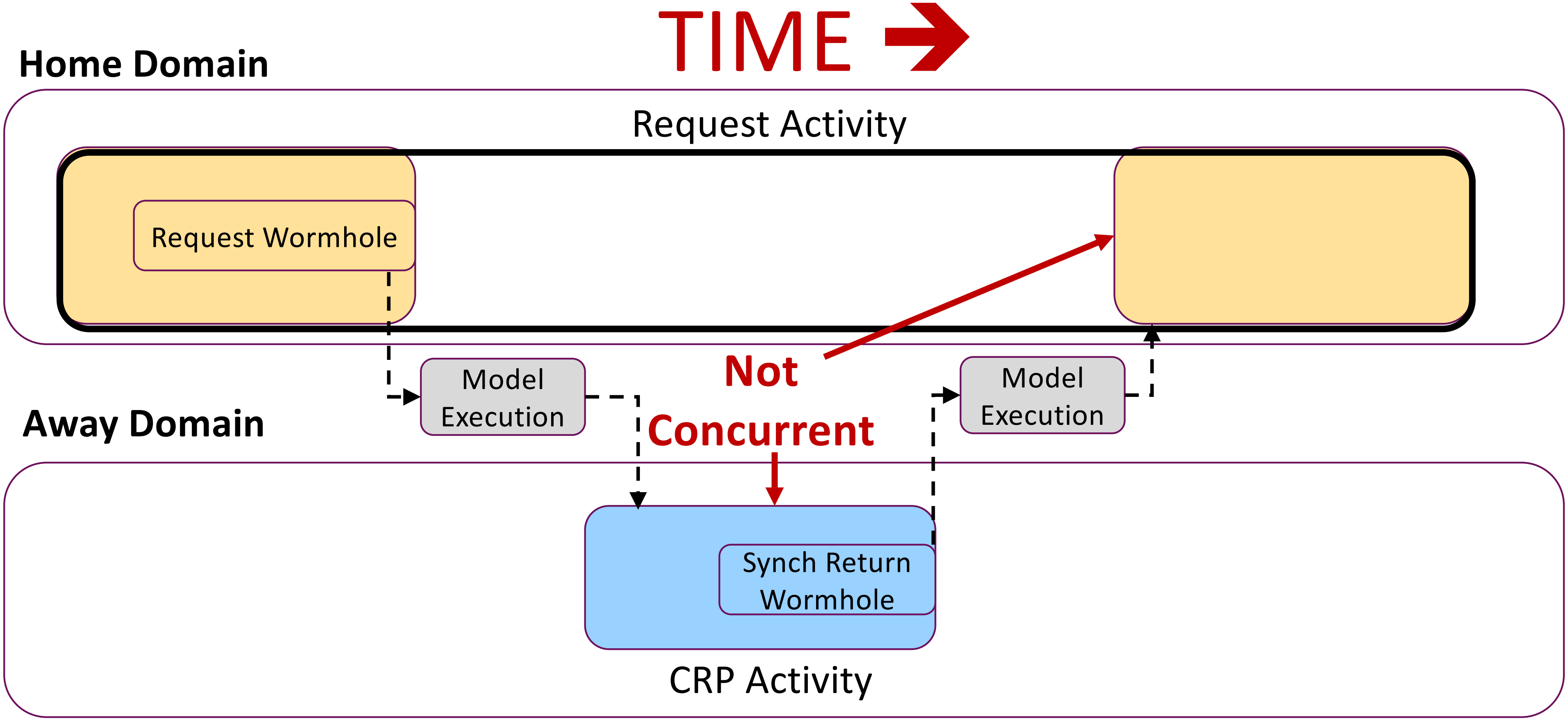
New Concepts

- **Request Wormhole** – New action in Home to request a bridge service
- **Synchronous Return Wormhole** – New action in Away to effect a synchronous return
- **Return Coordinate** – Information required to perform a synchronous return. If needed, created by MX, passed via MX, stored in Away, used in Away with Synchronous Return.
- **Asynchronous Return Wormhole** – New action in Away to effect an asynchronous return
- **Transfer Vector** – Information required to perform an asynchronous return. Started in Home, completed by MX, stored in Away, used in Away with Asynchronous Return.

Asynchronous Behavior and Concurrency



Synchronous Behavior and Concurrency



Initial Analysis Focus

Bridge Development Phases

- **Specification**: Specify Bridge Endpoints
- **Connection**: Connect Bridge Endpoints
- **Execution**: Develop MX code to support connected Bridge Endpoints

Additional Details

- **Specification**: Specify Bridge Endpoints
  - Request Wormholes, External Events, Synchronous Services and Return Wormholes
    - Behavior
    - Data
- **Connection**: Connect Bridge Endpoints
  - Match Request Wormholes to External Events or Synchronous Services
  - Populate the participating domains
  - Develop correspondences between data values that cross the domain boundary and address semantic shifts between domains
- **Execution**: Develop MX code to support connected Bridge Endpoints

Synchronous Service vs External Event (CRPs)

Reminder

- An activity that provides a bridge service is activated in the Away domain:
  - by an event (External Event) because the activity to provide the service needs to be coordinated with other activities possibly executing in the Away domain or
  - by an invocation (Synchronous Service) because the activity to provide the service does not need to be coordinated with other activities possibly executing in the Away domain

Implications

- This difference says nothing about whether the Home domain will experience the service asynchronously or synchronously. The Home domain has to indicate this via the Request Wormhole.
- Both CRPs are simply an activity, one activated by an event and one by an invocation. They have identical capabilities and behavior.
- Both CRPs can contain a synchronous return or an asynchronous return or neither.

Specification for Control Reception Point Interface (Away)

Interface Specifications

- ID
- Meaning
- Processing specified in CRP activity
- Inputs (to activity)
  - Data items (pass by value)
  - Return Type (stored by activity if present)
    - Transfer Vector (TV) or
    - Return Coordinate (RC)* or
    - None
- Outputs (requires a TV or RC input)
  - Data Items (pass by value)
  - Stored Return Type

*Produced by software architecture if required

Types of Control Reception Points

Type	Return Type	Outputs
CRP-1	Return Coordinates	Y
	Return Coordinates	N**
CRP-2	Transfer Vector	Y
CRP-3	Transfer Vector	N
	None	Y***
CRP-4	None	N

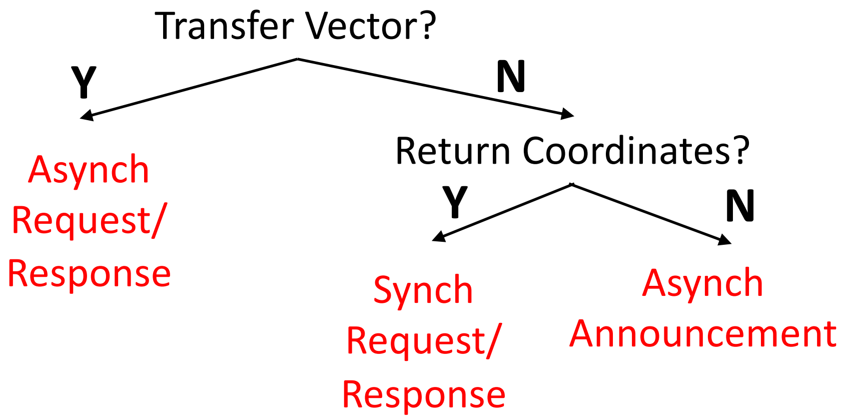
**Not supported. Return Coordinate not produced w/o Outputs. (Case #1, pg 5)
***Not supported. Outputs require a Return Coordinate or a Transfer Vector

Behavior for a Control Reception Point (Away)

Types of Control Reception Points

Type	Return Type	Outputs
CRP-1	Return Coordinates	Y
CRP-2	Transfer Vector	Y
CRP-3	Transfer Vector	N
CRP-4	None	N

Behavior Provided By Control Reception Points



Transfer Vector?

Y

N

Asynch Request/ Response

Return Coordinates?

Y

N

Synch Request/ Response

Asynch Announcement

Behavior of Control Reception Points

Type	Behavior
CRP-1	Synch Request/Response
CRP-2,3	Asynch Request/Response
CRP-4	Announcement

Specification for Request Wormhole (Home)

Specifications

- ID
- Meaning
- Input data items
- Output data items
- Transfer Vector or None

Types of Request Wormholes

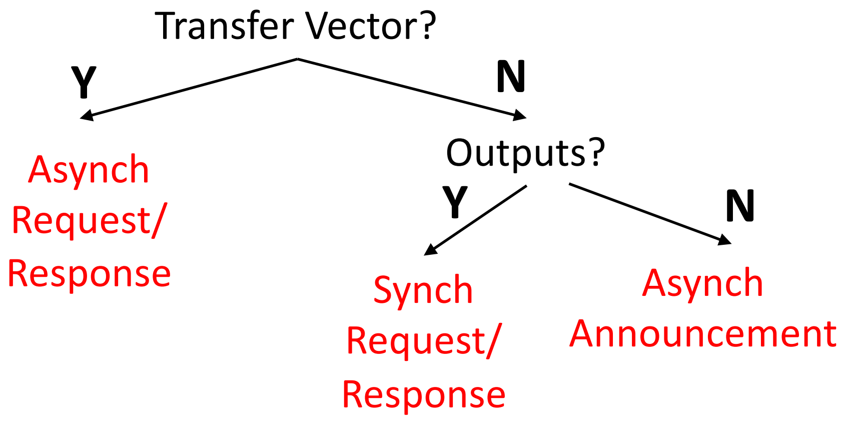
Type	Return Type	Outputs
RQW-1	No Transfer Vector	Y
RQW-2	Transfer Vector	N
RQW-3	Transfer Vector	Y
RQW-4	No Transfer Vector	N

Behavior for Request Wormhole (Home)

Types of Request Wormholes

Type	Return Type	Outputs
RQW-1	No Transfer Vector	Y
RQW-2	Transfer Vector	N
RQW-3	Transfer Vector	Y
RQW-4	No Transfer Vector	N

Behavior Expected By Request Wormholes



Transfer Vector?

Y

Asynch Request/ Response

N

Outputs?

Y

Synch Request/ Response

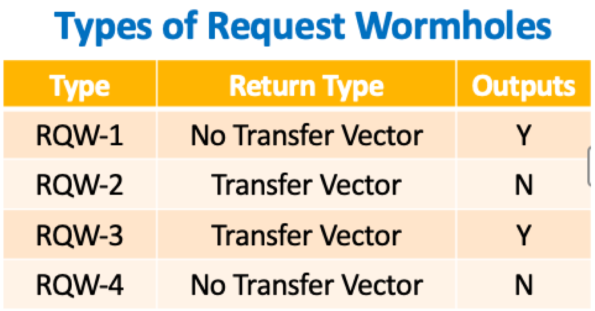
N

Asynch Announcement

Behavior of Request Wormholes

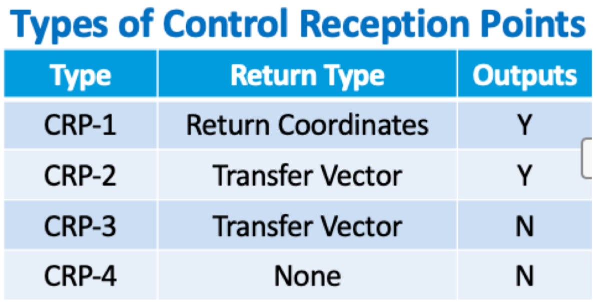
Type	Behavior
RQW-1	Synch Request/Response
RQW-2,3	Asynch Request/Response
RQW-4	Announcement

Matching a Request Wormhole with a CRP via Spec



Types of Request Wormholes

Type	Return Type	Outputs
RQW-1	No Transfer Vector	Y
RQW-2	Transfer Vector	N
RQW-3	Transfer Vector	Y
RQW-4	No Transfer Vector	N



Types of Control Reception Points

Type	Return Type	Outputs
CRP-1	Return Coordinates	Y
CRP-2	Transfer Vector	Y
CRP-3	Transfer Vector	N
CRP-4	None	N

Constructing the Bridge:
"For each request wormhole in one domain (Home), we must identify a synchronous service or an external event (CRP) in another domain (Away) ."

- Bridges & Wormholes paper

Matching a Request Wormhole with a CRP via Behavior

Match on
Bridge Behavior

HOME
Behavior of Request Wormholes

Type	Behavior
RQW-1	Synch Request/Response
RQW-2,3	Asynch Request/Response
RQW-4	Announcement

AWAY
Behavior of Control Reception Points

Type	Behavior
CRP-1	Synch Request/Response
CRP-2,3	Asynch Request/Response
CRP-4	Announcement

Observations

1. Typing the behavior of Request Wormholes and CRPs facilitates matching.
2. Matching I/O data items remains to be done for final match.
3. A given CRP (bridge service) in Away can only support 1 type of bridge behavior based on the type of return wormhole it contains.
4. Thus the behavior of a bridge is determined by the Away domain not the Home domain.

Specifying Return Wormholes (Away)

Synchronous Return Wormhole

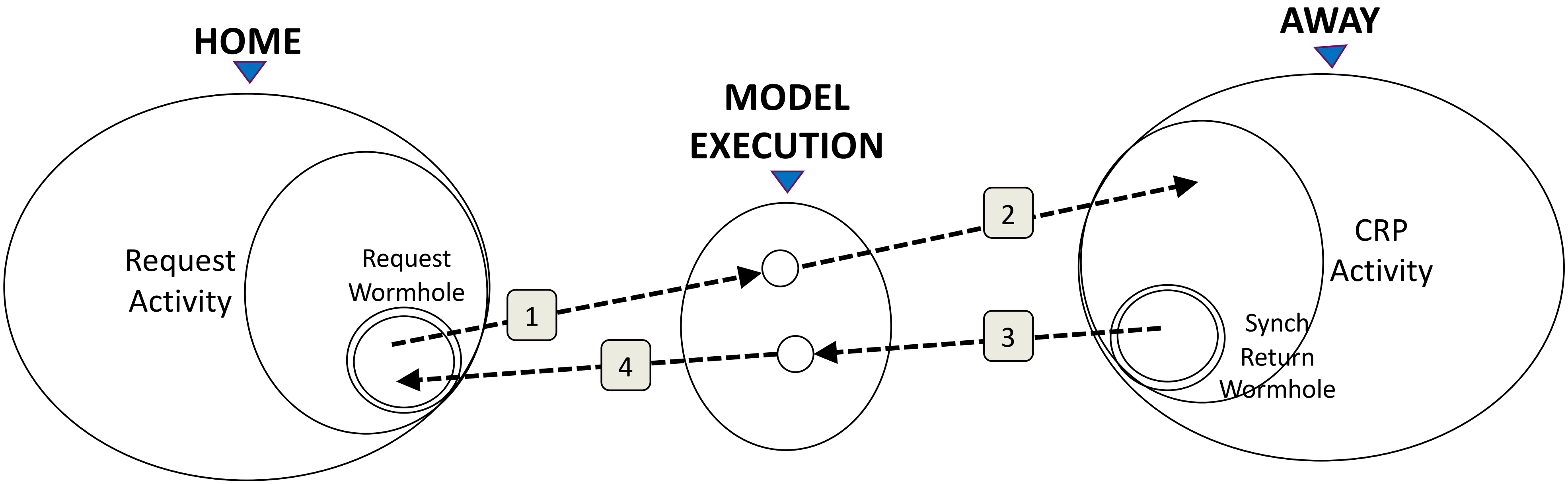
- ID
- Meaning
- Return Coordinate
- 1+ “return” data items

Asynchronous Return Wormhole

- ID
- Meaning
- Transfer Vector
- 0 ➔ 1+ “return” data items

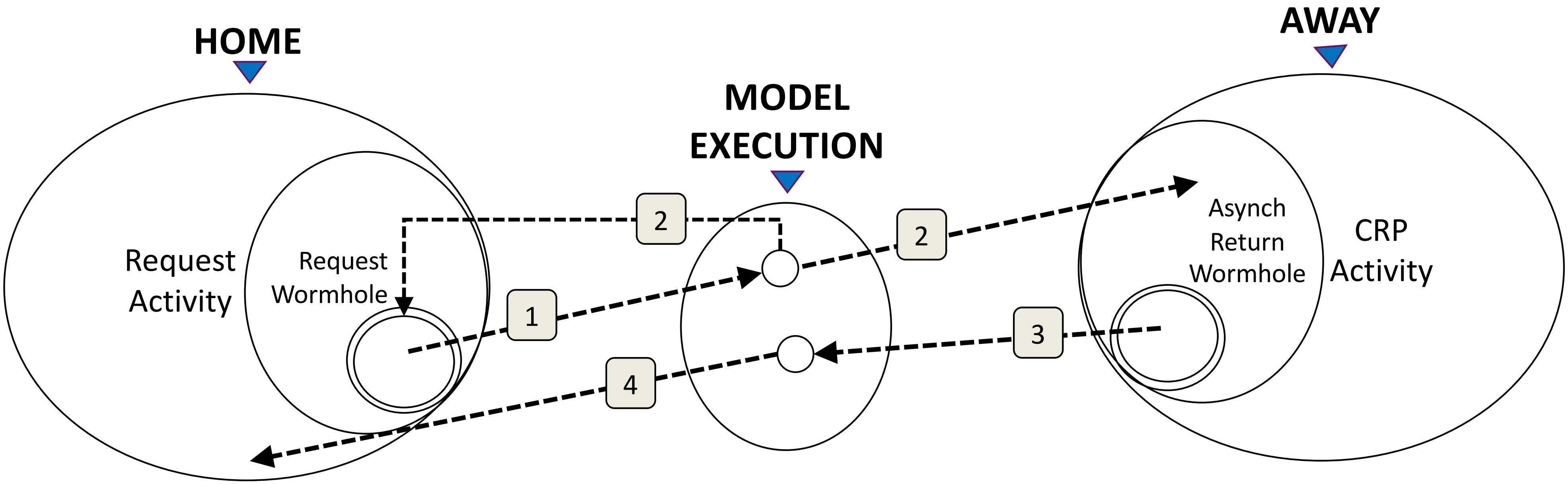
Remember: Announcement behavior does not require a Return Wormhole

Simplified View of a Synchronous Bridge Scenario



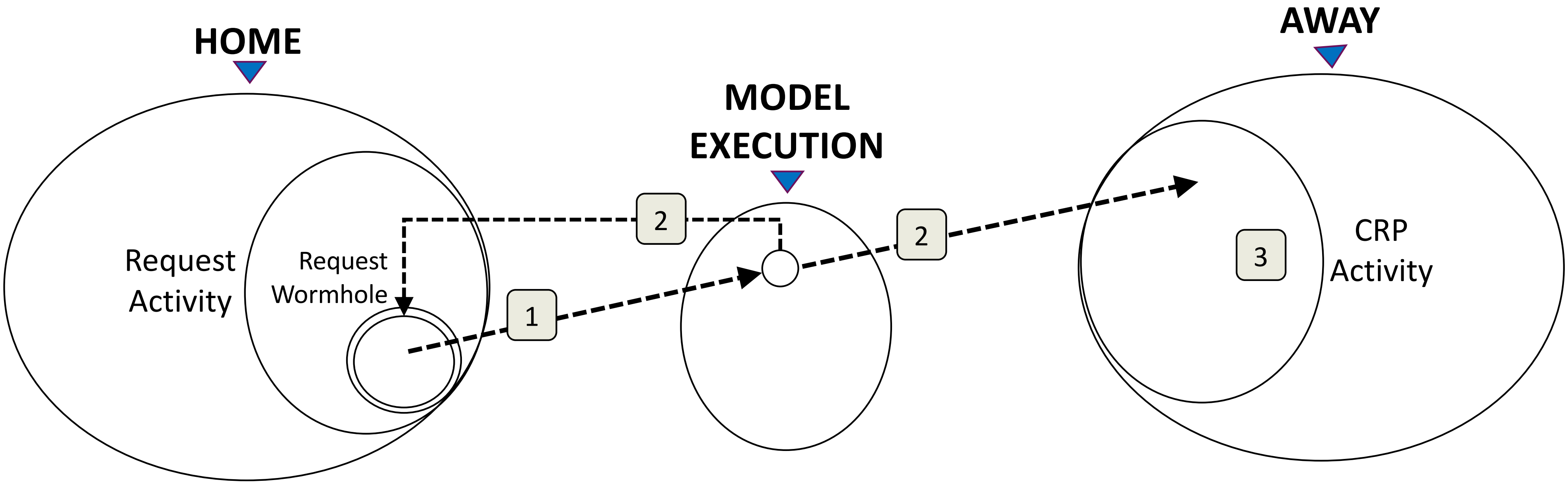
1. A Request Wormhole action executes in **Home** which suspends the Request Wormhole action and causes MX to…
2. Initiate activation of the associated CPR activity (w/input data) in **Away** which executes until…
3. Eventually, a Synchronous Return Wormhole action executes in the CRP Activity in **Away** which causes MX to…
4. Resume the Request Wormhole action in **Home** (w/requested return data).

Simplified View of an Asynchronous Bridge Scenario



1. A Request Wormhole action executes in **Home** which suspends the Request Wormhole action and causes MX to…
2. Initiate activation of the associated CPR activity in **Away** and resume the Request Wormhole action in **Home**.
3. Eventually, an Asynchronous Return Wormhole action executes in the CRP Activity in **Away** which causes MX to…
4. Post the “Populated Return Vector” event in **Home**

Simplified View of an Announcement Bridge Scenario



1. A Request Wormhole action executes in **Home** which suspends the Request Wormhole action and causes MX to…
2. Initiate activation of the associated CPR activity in **Away** and resume the Request Wormhole action in **Home**.
3. Eventually, the CRP Activity in **Away** completes without executing any return wormhole actions.

Questions? Comments?? Suggestions???

Preview of Issues and Proposed Improvements

As-Is Bridges & Wormholes

- 1 Request Wormhole to address:
  - synchronous,
  - asynchronous and
  - announcement behavior
- 2 Return Wormholes to address:
  - synchronous and
  - asynchronous behavior

Results

- CRP can only provide 1 behavior based on Return Wormhole used
- Away determines bridge behavior
- Home must match Away behavior

Improved Bridges and Wormholes

- New data type, Return Mechanism w/subtypes:
  - Transfer Vector
  - Return Coordinates
- 3 Request Wormholes, 1 per behavior
  - Explicit interface
  - Clarifies Home’s desired behavior
- 1 Return Wormhole
  - Away provides stored Return Mechanism
  - MX uses subtype to provide requested behavior

Results

- CRP can provide both synch and asynch behavior
- CRP can provide different behavior to different Homes
- Home determines bridge behavior