

Concurrent Interactions in The Sims 4

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Outline

Outline

- Interactions

Outline

- Interactions
- Constraints

Outline

- Interactions
- Constraints
- Interaction Queue

Outline

- Interactions
- Constraints
- Interaction Queue
- Transitions

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- Interactions
- Constraints
- Interaction Queue
- Transitions
- Socials

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- Interactions
- Constraints
- Interaction Queue
- Transitions
- Socials
- Q&A



Interactions

The Sims Architecture

- The world is built using game objects

The Sims Architecture

- The world is built using game objects
- Game objects provide interactions
 - Sims are objects too!

The Sims Architecture

- The world is built using game objects
- Game objects provide interactions
 - Sims are objects too!
- Sims run interactions
 - Interactions are fundamental unit of behavior

Multitasking

- Natural
 - People do multiple things at the same time

Multitasking

- Natural
 - People do multiple things at the same time
- Frequently requested feature

Multitasking

- Natural
 - People do multiple things at the same time
- Frequently requested feature
- Systematic approach is valuable
 - Ad hoc implementation is lots of work, inconsistent results

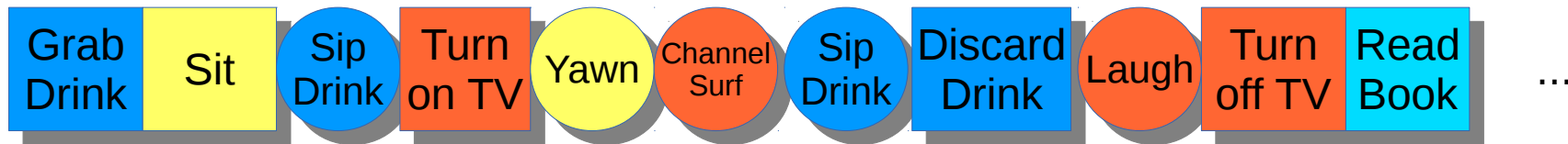
Concurrency vs Multitasking

- No true concurrent execution
 - This is a hard problem
 - Deadlock, race conditions, etc...

Concurrency vs Multitasking

- No true concurrent execution
 - This is a hard problem
 - Deadlock, race conditions, etc...
- Multitasking
 - Context switching
 - Cooperative

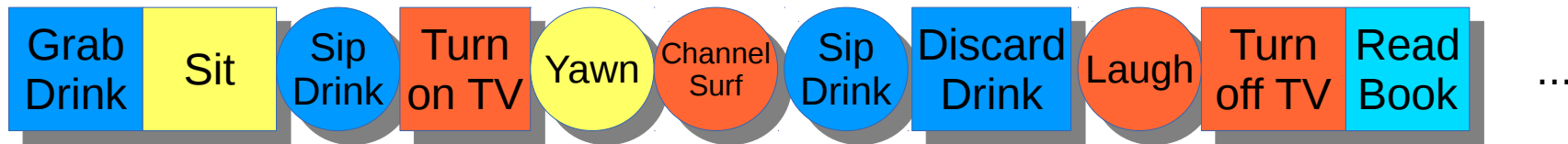
Multitasking



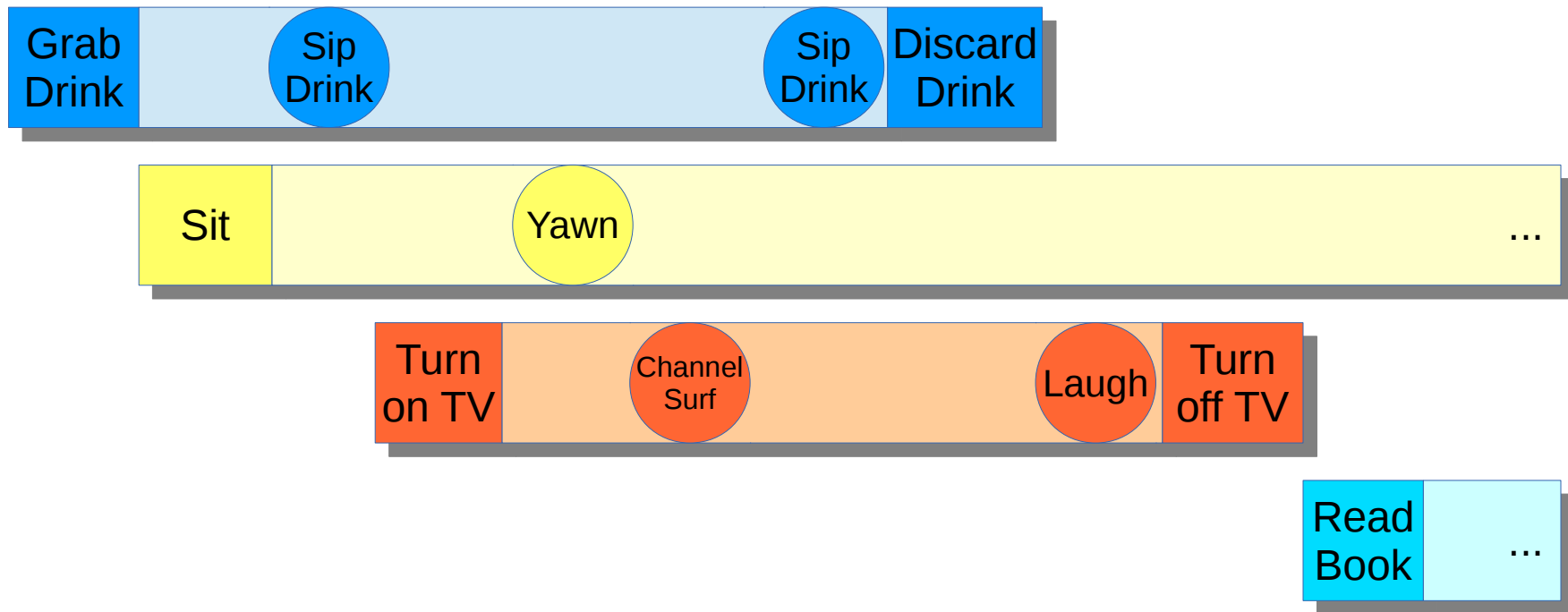




Multitasking

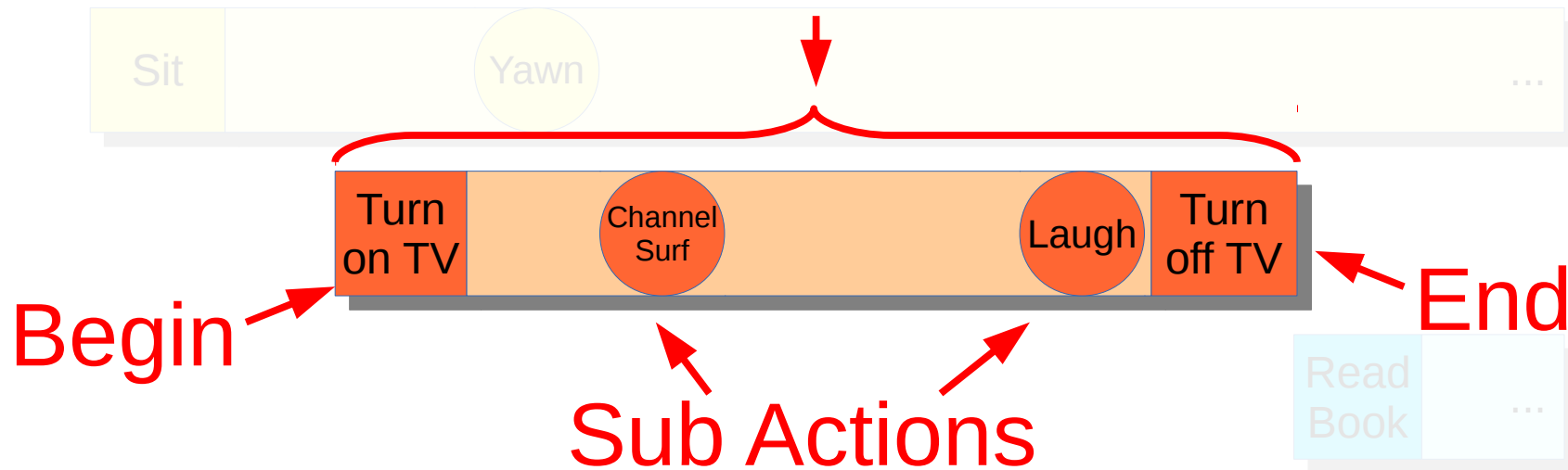


Multitasking



Interactions

Watch TV
Interaction



Running Interactions

- Each Sim has
 - A set of **active** interactions
 - An ordered queue of **pending** interactions

Running Interactions

- Each Sim has
 - A set of **active** interactions
 - An ordered queue of **pending** interactions
- Sub-actions run “inside” active interactions

Sub Actions

- Compatible with all running interactions

Sub Actions

- Compatible with all running interactions
- Selected using weighted random

Sub Actions

- Compatible with all running interactions
- Selected using weighted random
- Can be limited with additional tests



Constraints

Rules

- Can I perform an action?

Rules

- Can I perform an action?
 $\neg \text{Condition} \rightarrow \neg \text{Action}$

Rules

- Can I perform an action?
 $\neg \text{Condition} \rightarrow \neg \text{Action}$
- How do I perform an action?

Rules

- Can I perform an action?
 $\neg \text{Condition} \rightarrow \neg \text{Action}$
- How do I perform an action?
 $\text{Action} \rightarrow \text{Condition}$

Rules

- Can I perform an action?
 $\neg \text{Condition} \rightarrow \neg \text{Action}$
- How do I perform an action?
 $\text{Action} \rightarrow \text{Condition}$
- Avoids duplicated logic

Constraints

- Data-driven rules

Constraints

- Data-driven rules
- Preconditions on running an interaction

Constraints

- Data-driven rules
- Preconditions on running an interaction
- Answer the questions
 - Can I run an interaction?
 - How do I run an interaction?

Position



Orientation



Animation Slot



Posture



Posture

Examples



Posture

Examples



Carrying

Doesn't need
hands



Carrying

Object in hand



Carrying

Needs hands



Surfaces

Object on
Surface



Surfaces

Empty surface



Line of Sight



Scoring Functions



Constraint Authoring

- Data driven
 - Animation: Position, posture, carry
 - XML Tuning: Geometry, orientation, surface
 - Script: Scoring function, line-of-sight

Constraint Combination

- Multitasking combines constraints

Constraint Combination

- Multitasking combines constraints
- Supported operations
 - Intersection
 - Union





ALPHA SOFTWARE

Interaction Compatibility

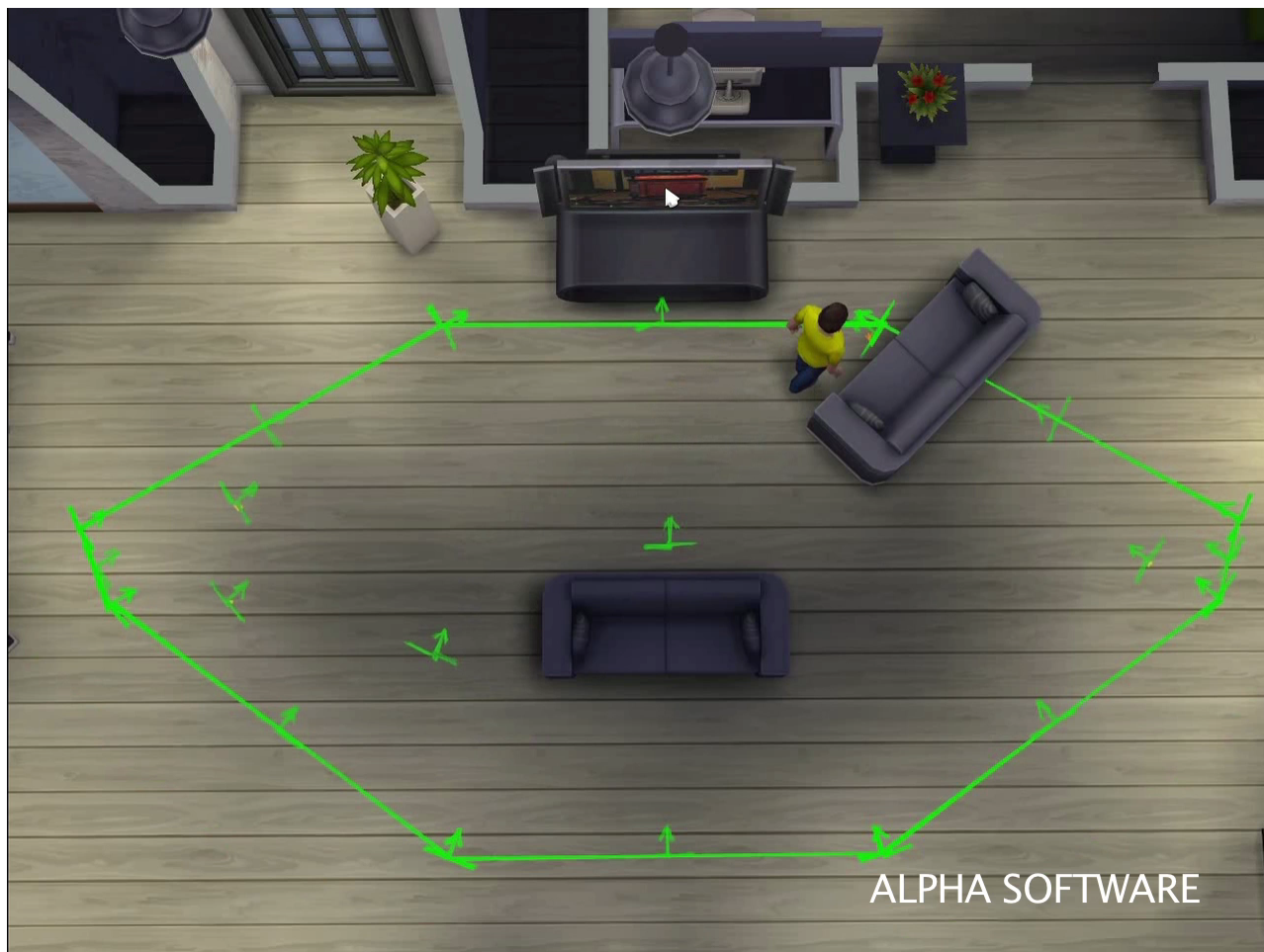
Q: Are interactions compatible?

Interaction Compatibility

Q: Are interactions compatible?

A: Yes, if the intersection of their constraints is non-empty







Interaction Queue

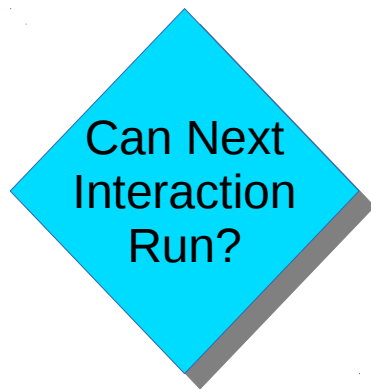
Interaction Queue

- Each Sim has
 - A set of **active** interactions
 - An ordered queue of **pending** interactions

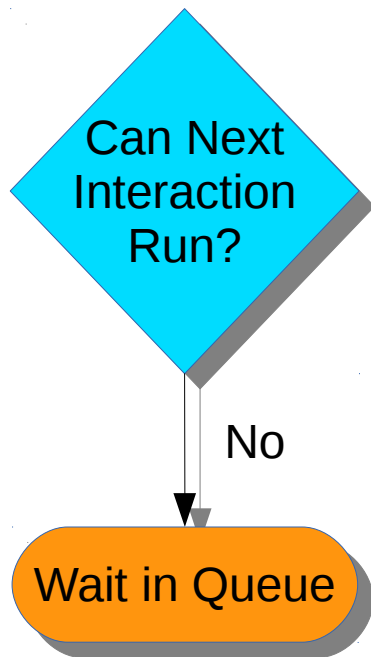
Interaction Queue

- Each Sim has
 - A set of **active** interactions
 - An ordered queue of **pending** interactions
- Interactions have priority
 - High (User directed)
 - Low (Autonomous)
 - Idle (Finished but still running)

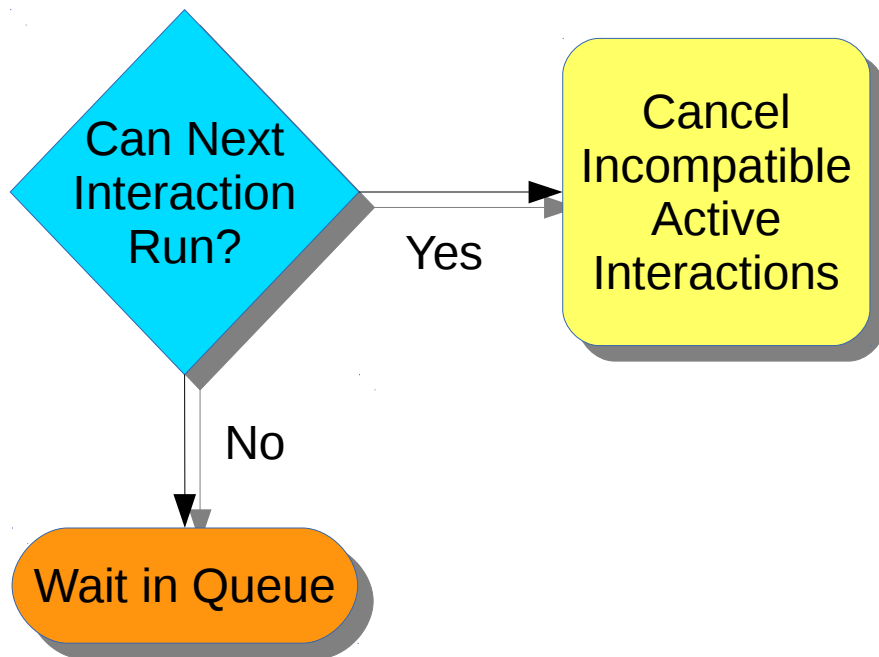
Queue Processing



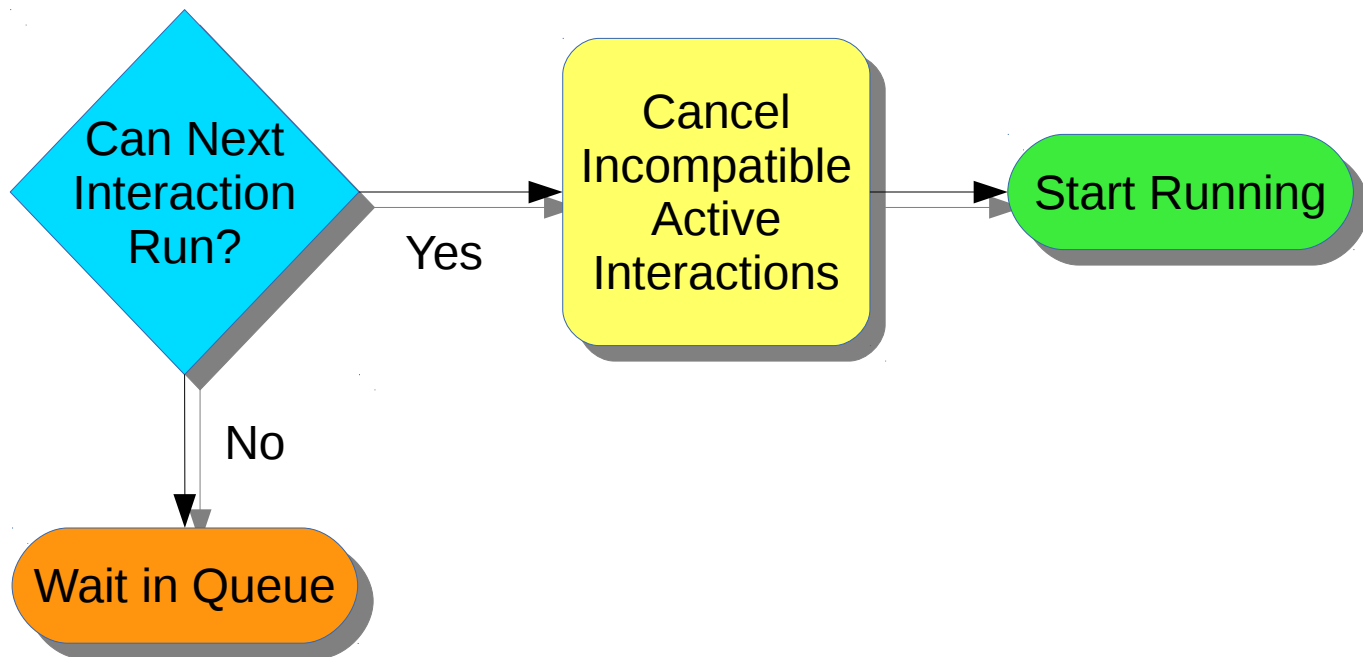
Queue Processing



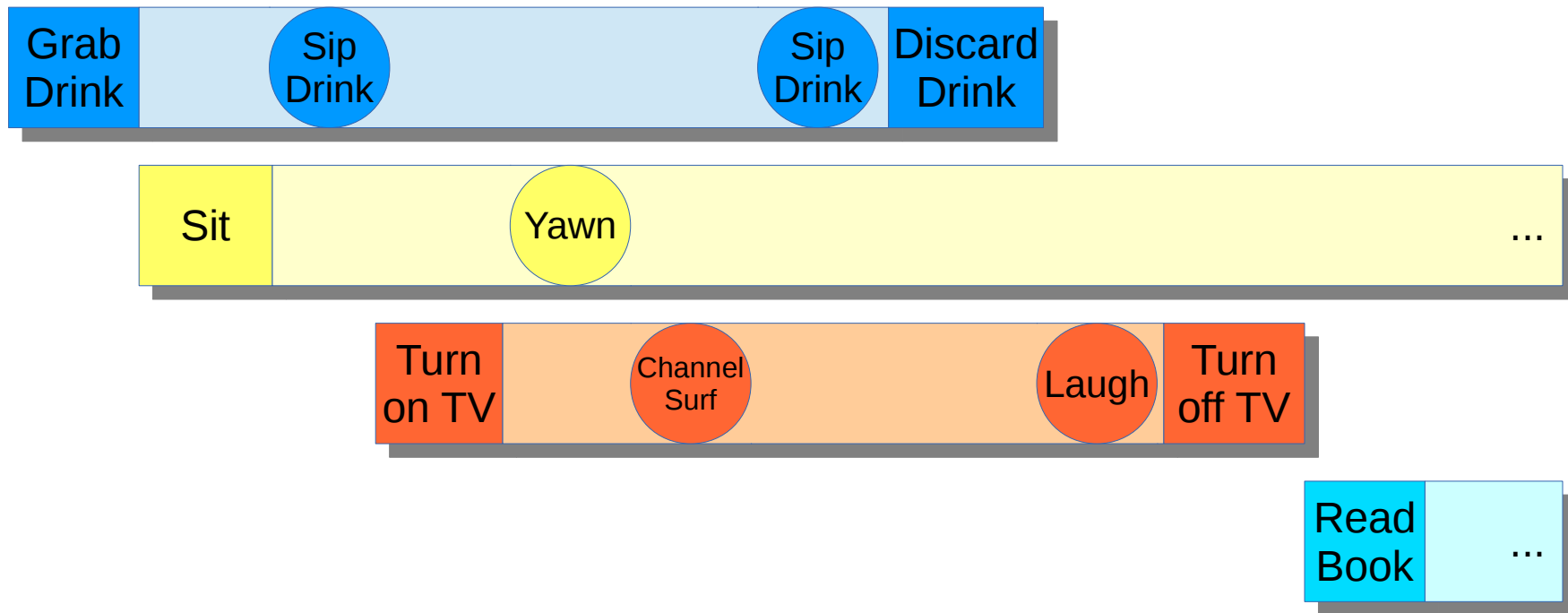
Queue Processing



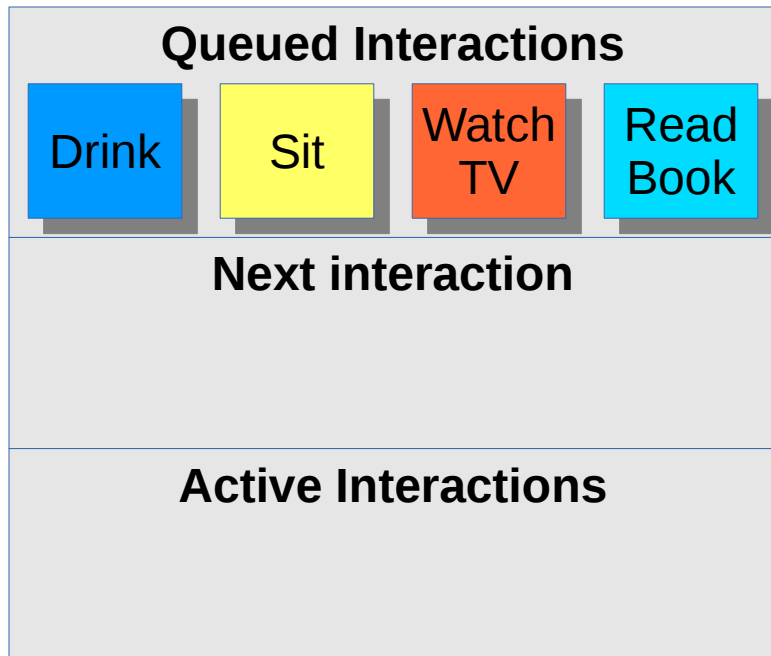
Queue Processing



Interaction Processing Example

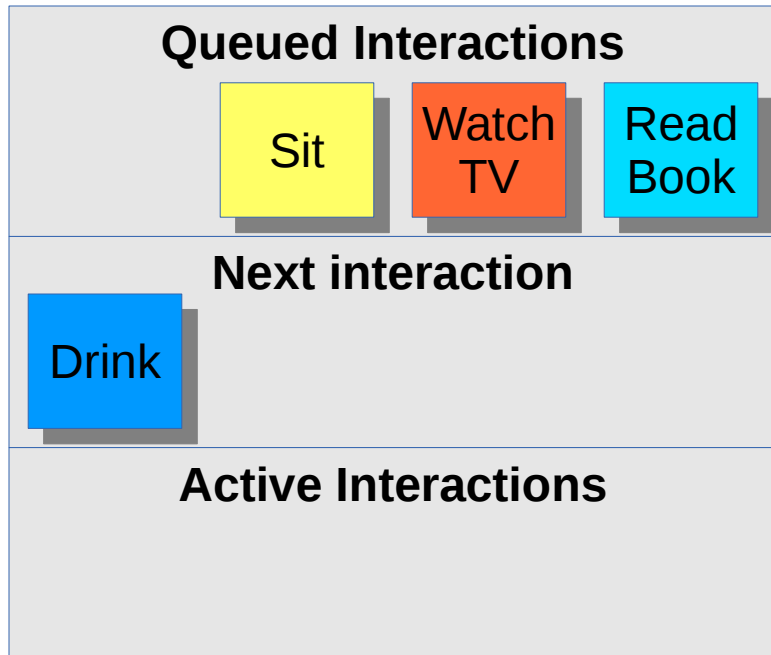


Interaction Processing Example



Where	How	Hands
Anywhere	Anything	Don't Care

Interaction Processing Example



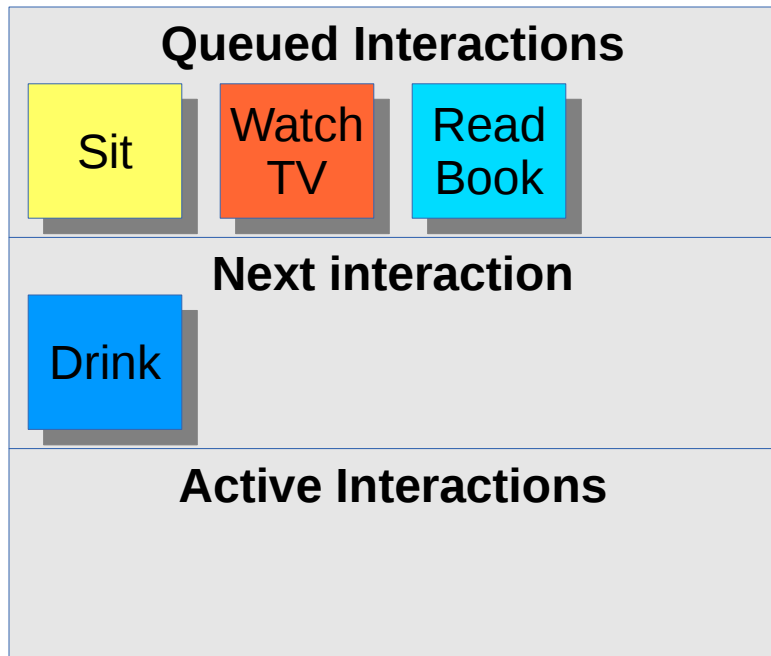
Where

How

Hands

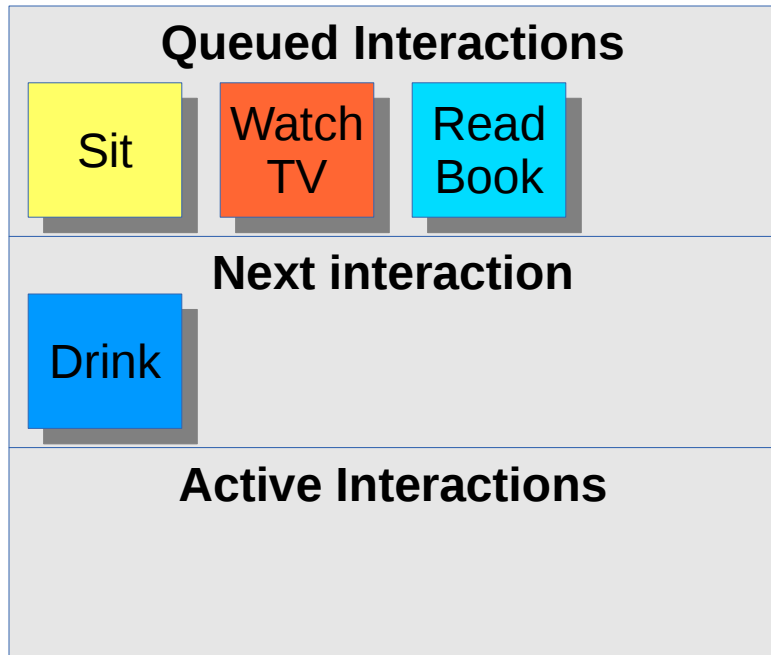
Anywhere	Anything	Don't Care

Interaction Processing Example



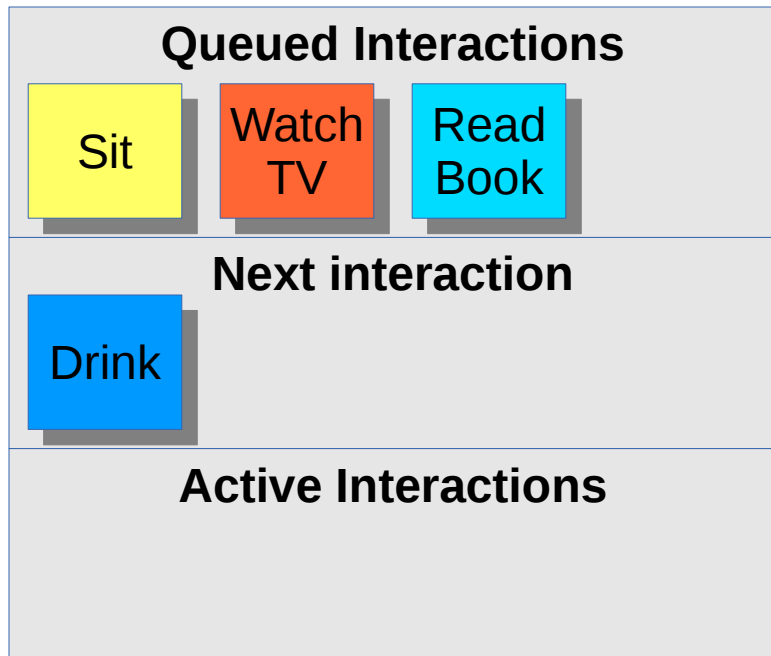
Where	How	Hands
Anywhere	Anything	Holding Drink
Anywhere	Anything	Don't Care

Interaction Processing Example



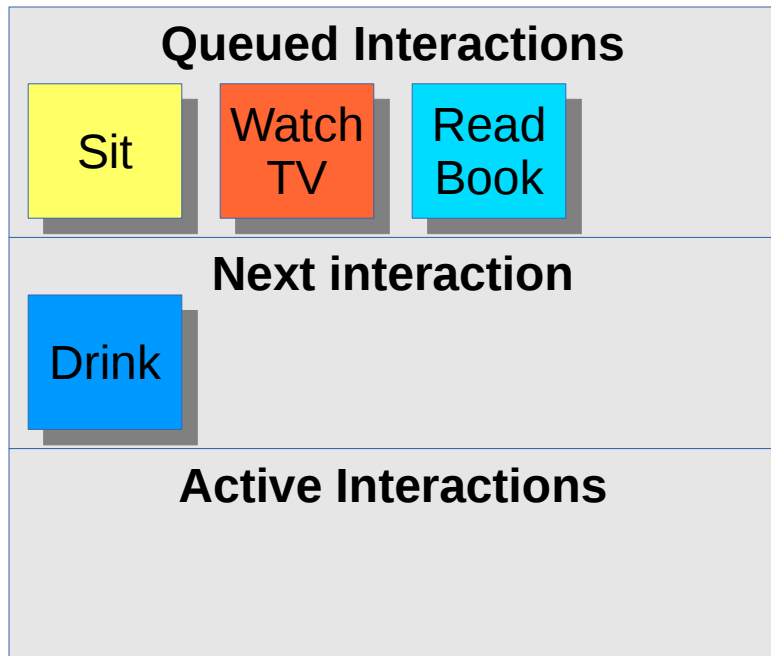
Where	How	Hands
Anywhere		
Anywhere	Anything	Don't Care

Interaction Processing Example



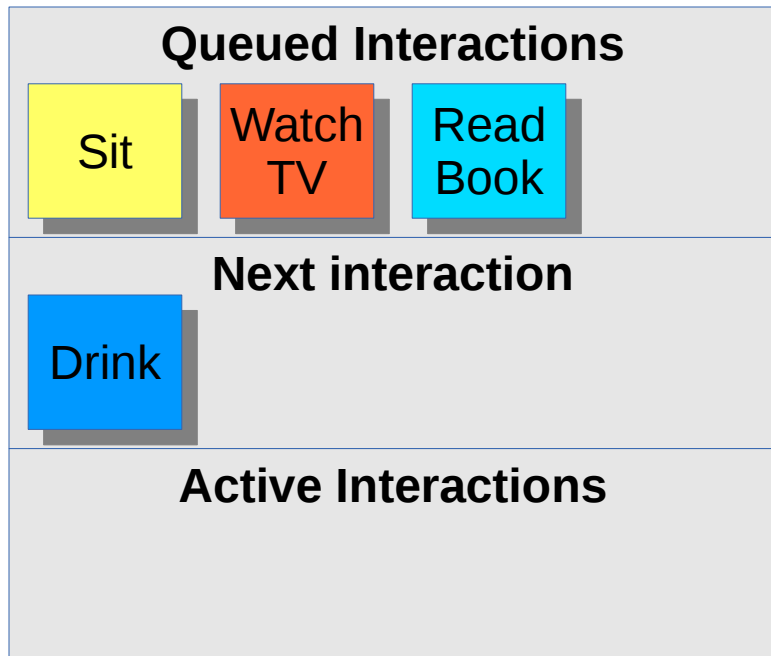
Where	How	Hands
Anywhere		
Anywhere	Anything	Don't Care

Interaction Processing Example



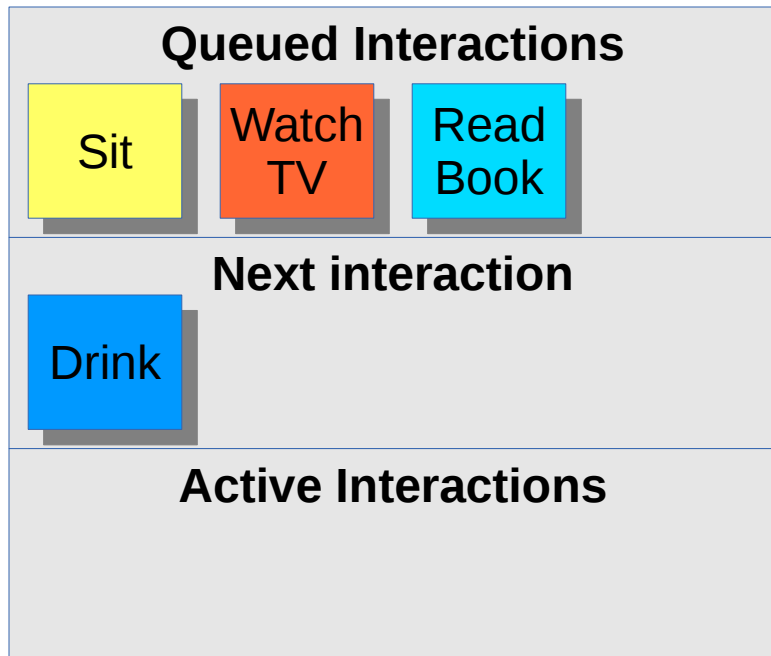
Where	How	Hands
Anywhere	Sit or Stand	
Anywhere	Anything	Don't Care

Interaction Processing Example



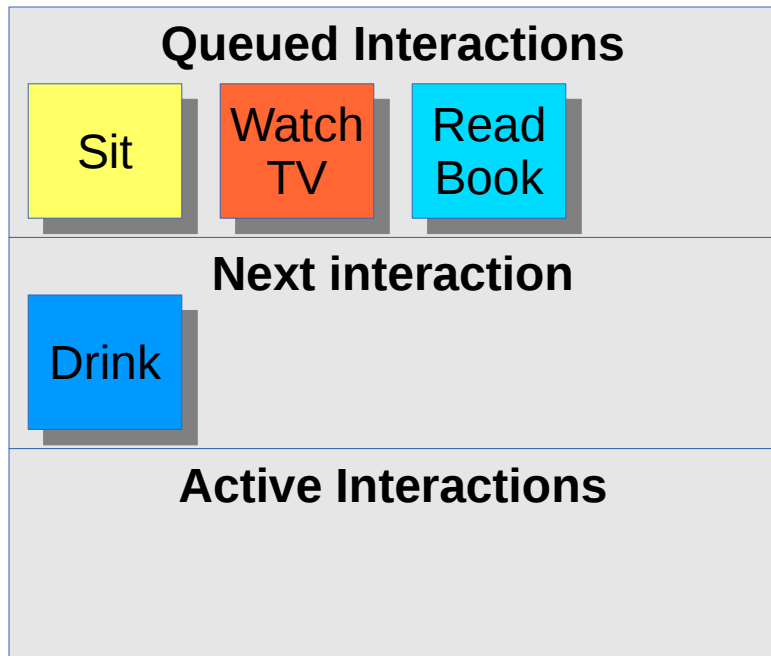
Where	How	Hands
Anywhere	Sit or Stand	
Anywhere	Anything	Don't Care

Interaction Processing Example



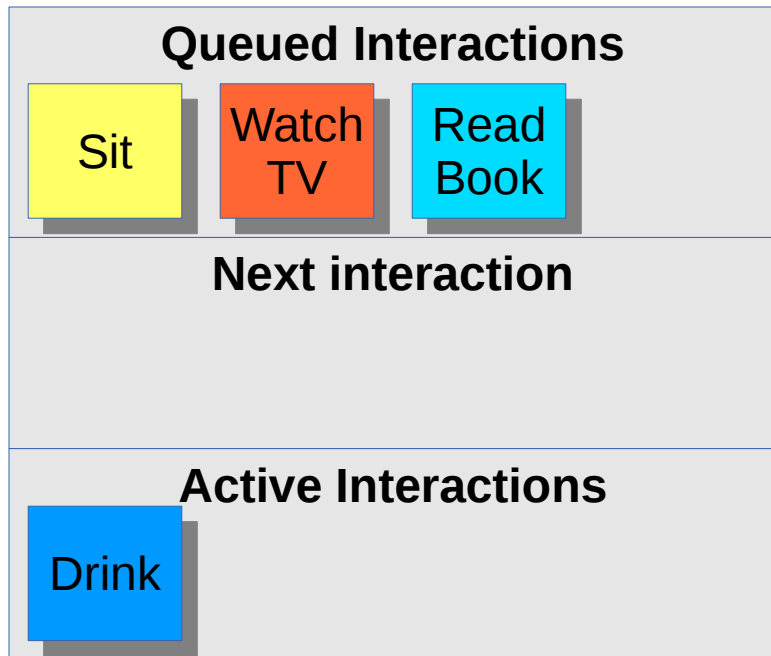
Where	How	Hands
Anywhere	Sit or Stand	Hold Drink
Anywhere	Anything	Don't Care

Interaction Processing Example



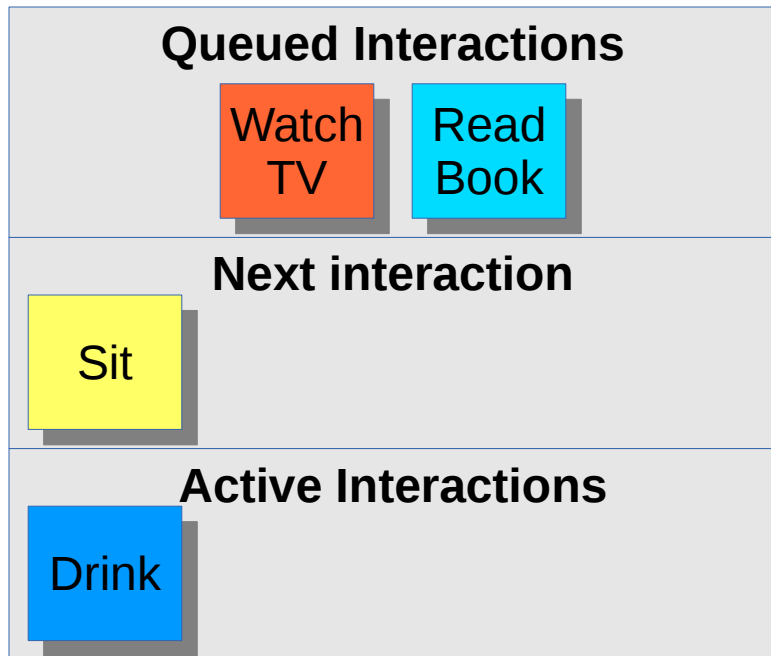
Where	How	Hands
Anywhere	Sit or Stand	Hold Drink
Anywhere	Anything	Don't Care

Interaction Processing Example



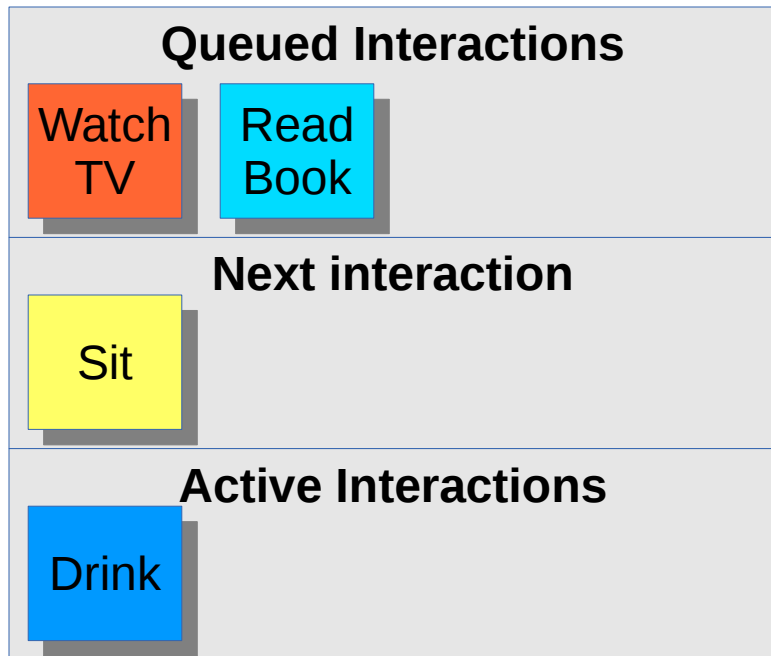
Where	How	Hands
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



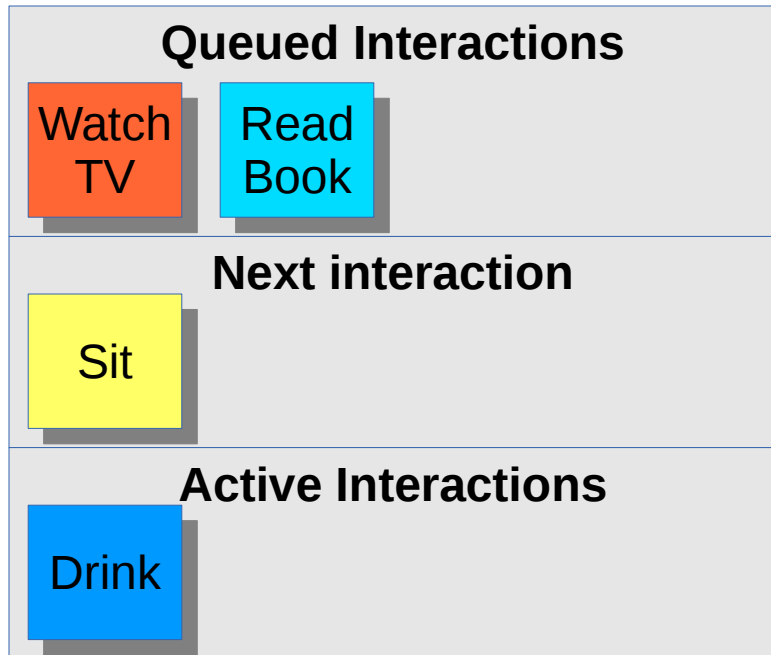
Where	How	Hands
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



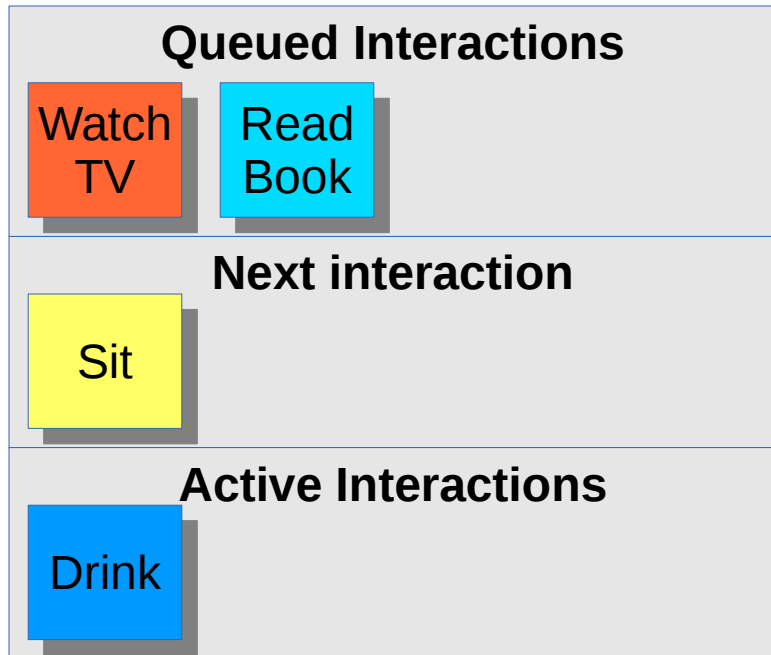
Where	How	Hands
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



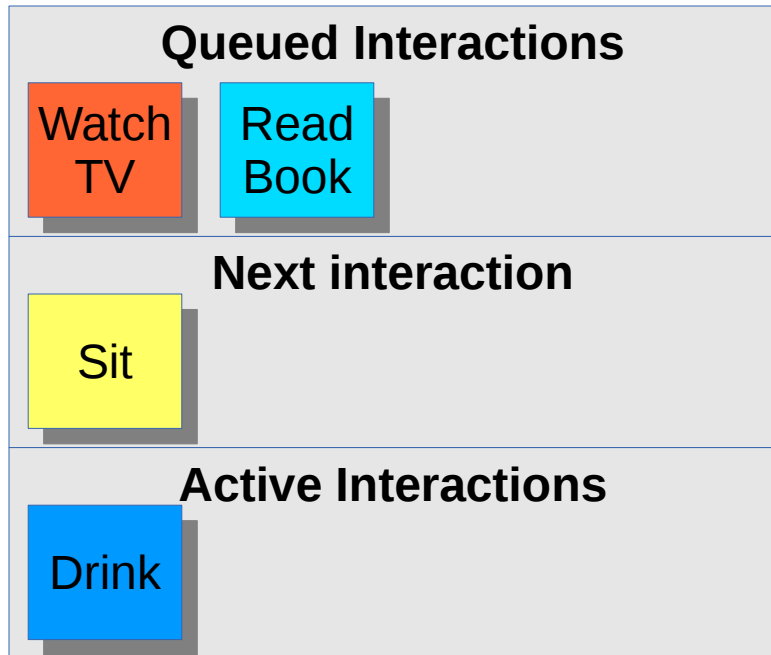
Where	How	Hands
On Seat		
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



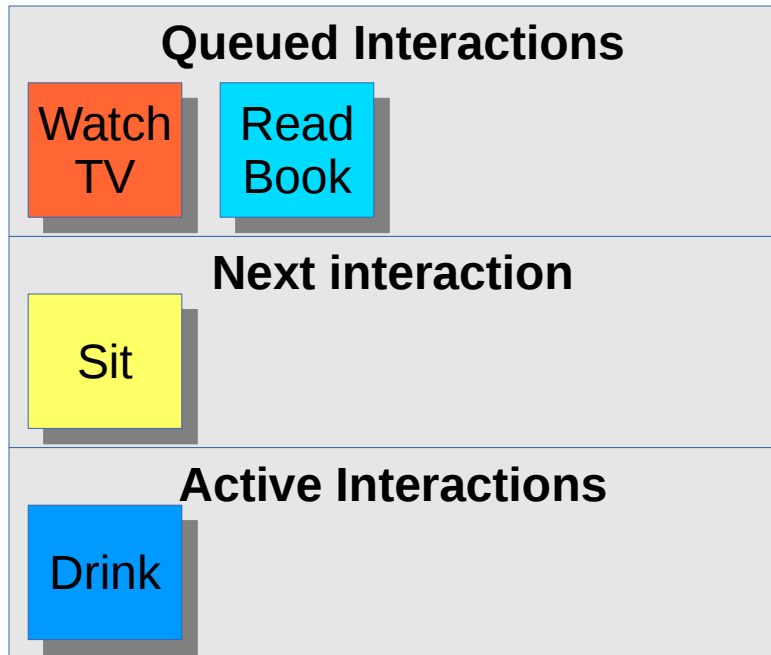
Where	How	Hands
On Seat		
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



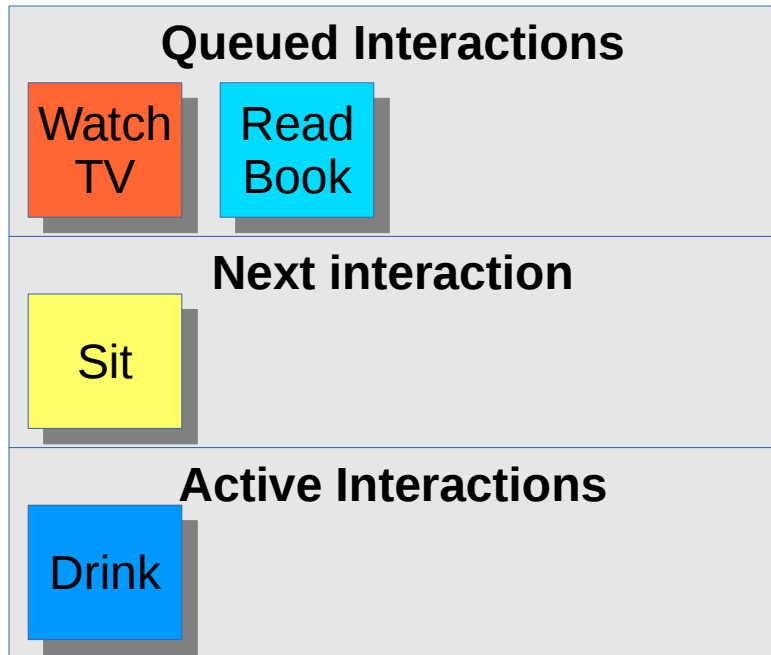
Where	How	Hands
On Seat	Sit	
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



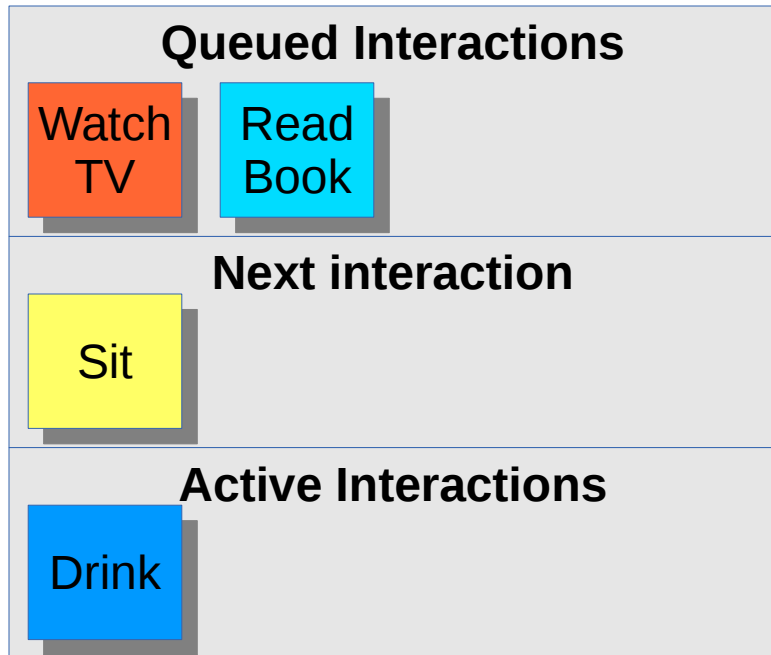
Where	How	Hands
On Seat	Sit	
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



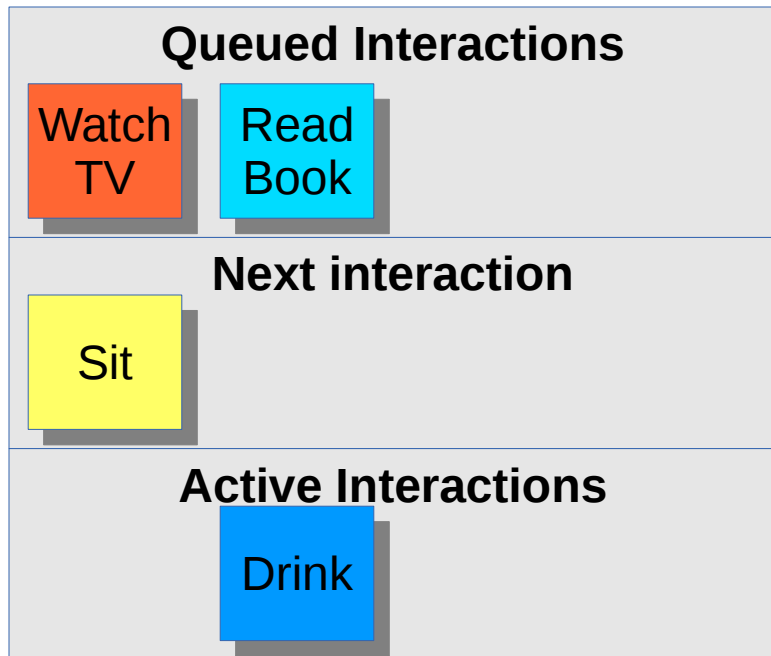
Where	How	Hands
On Seat	Sit	Don't Care
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



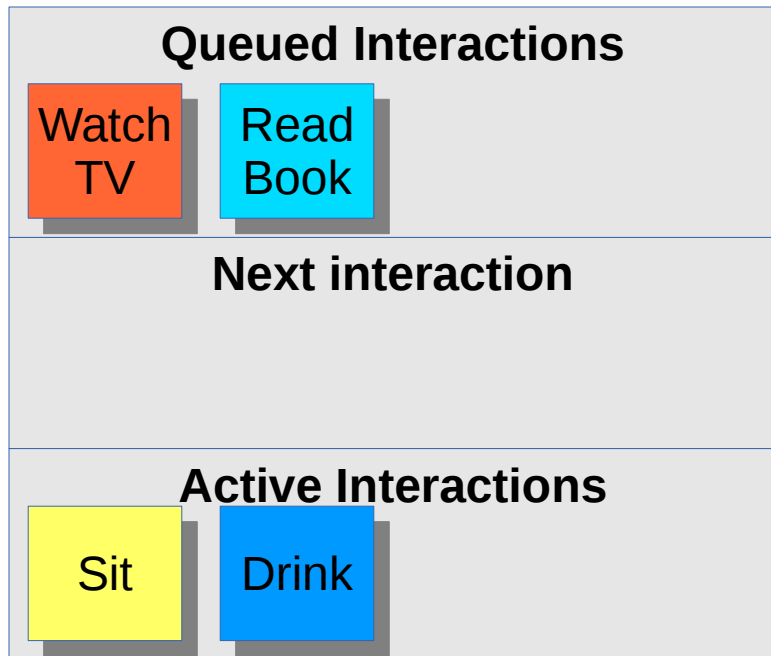
Where	How	Hands
On Seat	Sit	Don't Care
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



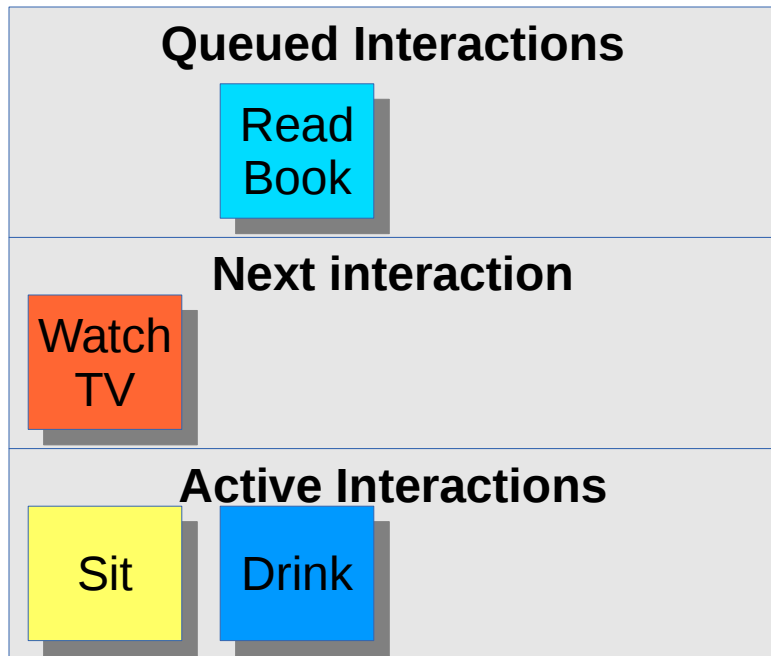
Where	How	Hands
On Seat	Sit	Don't Care
Anywhere	Sit or Stand	Hold Drink

Interaction Processing Example



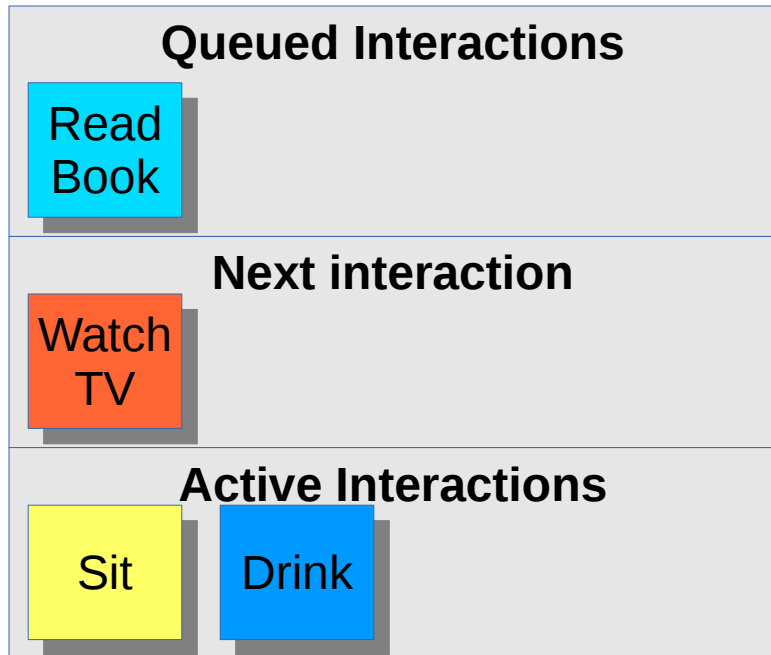
Where	How	Hands
On Seat	Sit	Hold Drink

Interaction Processing Example



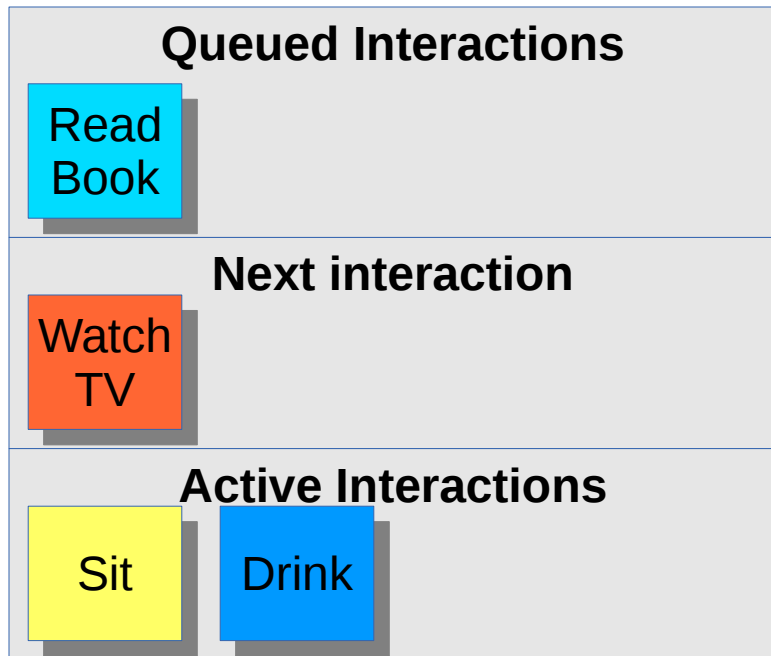
Where	How	Hands
On Seat	Sit	Hold Drink

Interaction Processing Example



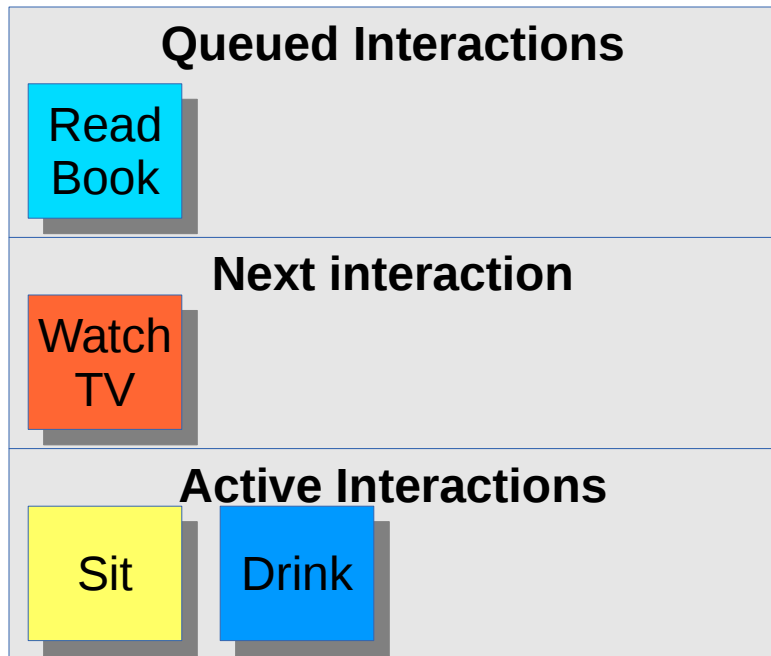
Where	How	Hands
On Seat	Sit	Hold Drink

Interaction Processing Example



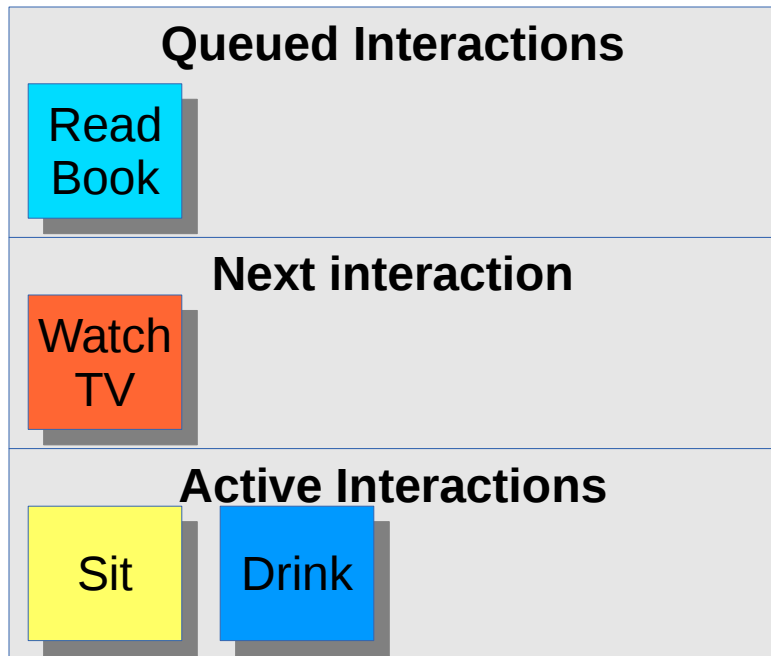
Where	How	Hands
In view, Facing		
On Seat	Sit	Hold Drink

Interaction Processing Example



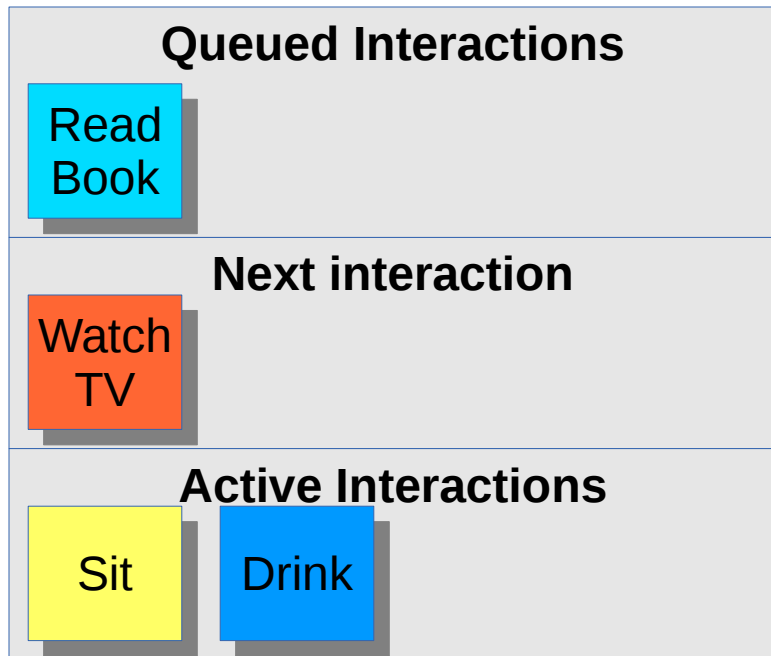
Where	How	Hands
In view, Facing		
On Seat	Sit	Hold Drink

Interaction Processing Example



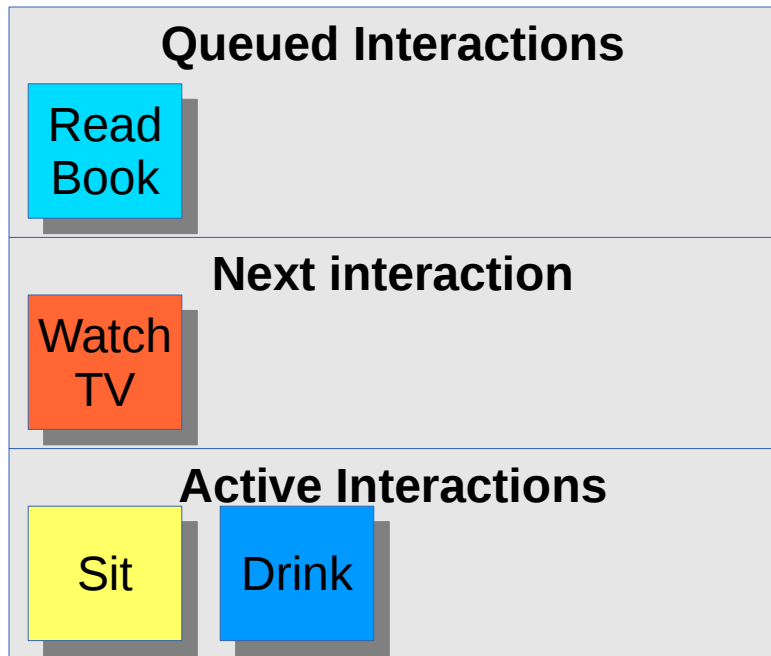
Where	How	Hands
In view, Facing	Sit or Stand	
On Seat	Sit	Hold Drink

Interaction Processing Example



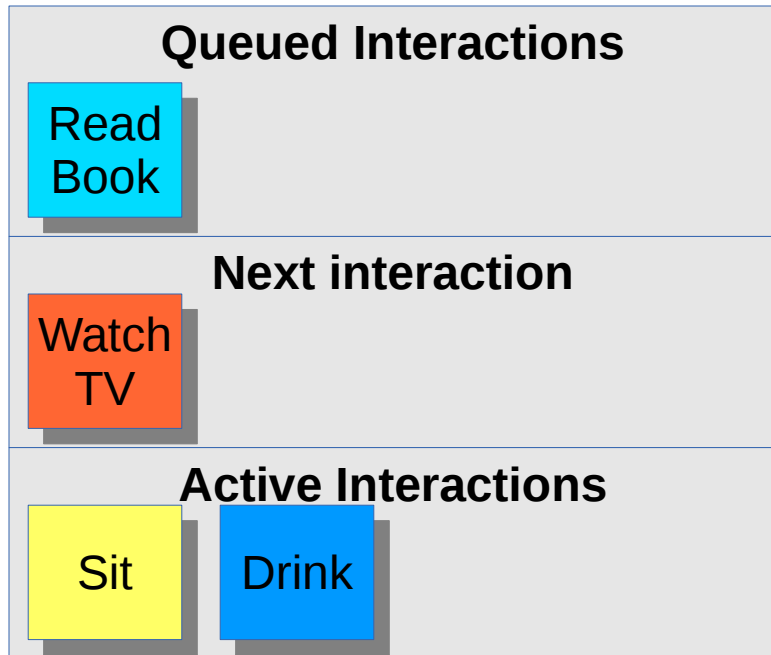
Where	How	Hands
In view, Facing	Sit or Stand	
On Seat	Sit	Hold Drink

Interaction Processing Example



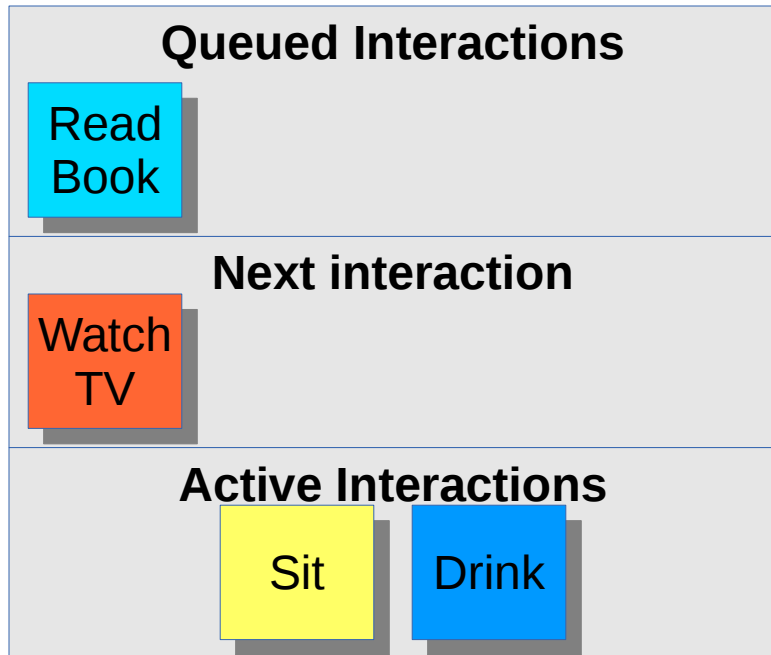
Where	How	Hands
In view, Facing	Sit or Stand	Don't Care
On Seat	Sit	Hold Drink

Interaction Processing Example



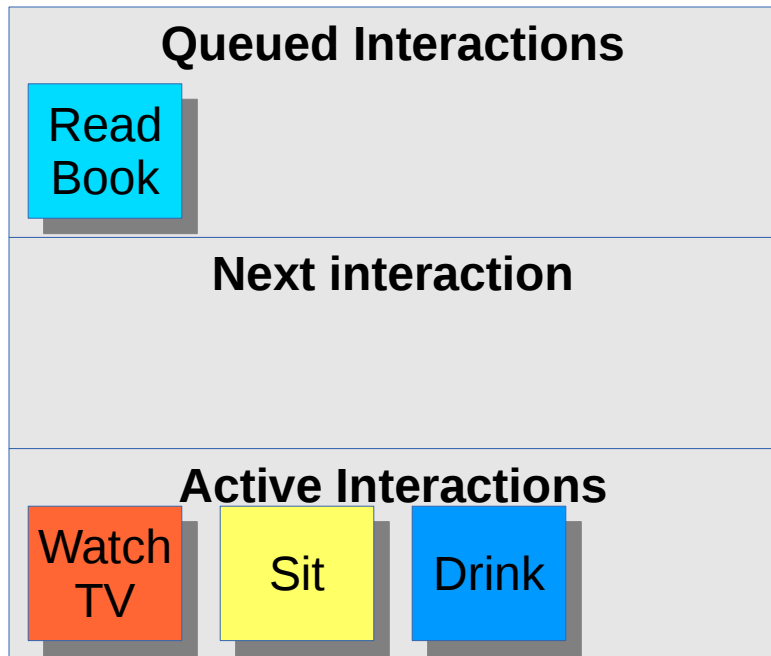
Where	How	Hands
In view, Facing	Sit or Stand	Don't Care
On Seat	Sit	Hold Drink

Interaction Processing Example



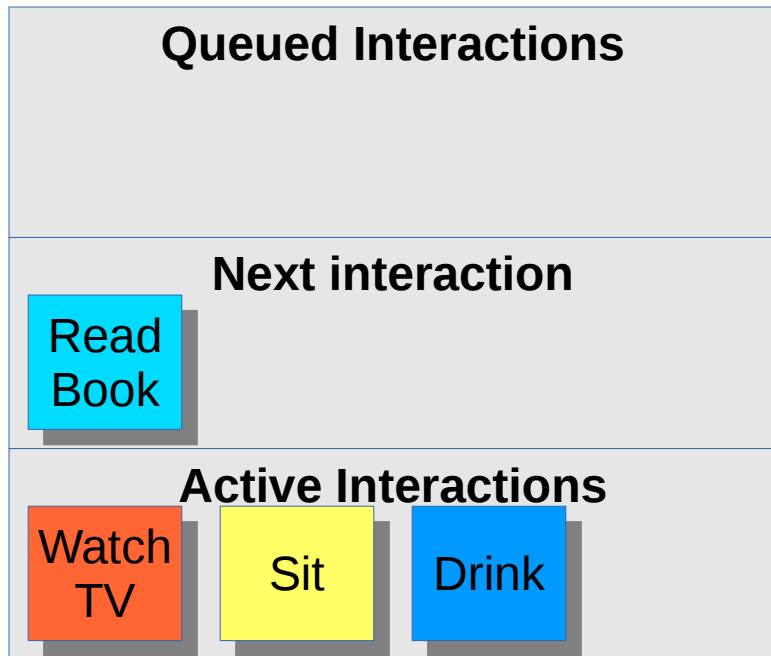
Where	How	Hands
In view, Facing	Sit or Stand	Don't Care
On Seat	Sit	Hold Drink

Interaction Processing Example



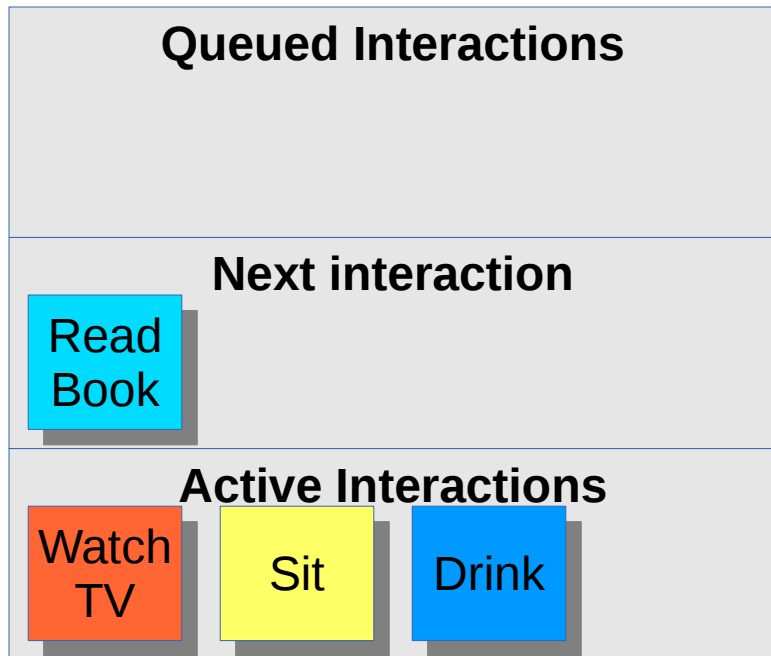
Where	How	Hands
On Seat	Sit	Hold Drink

Interaction Processing Example



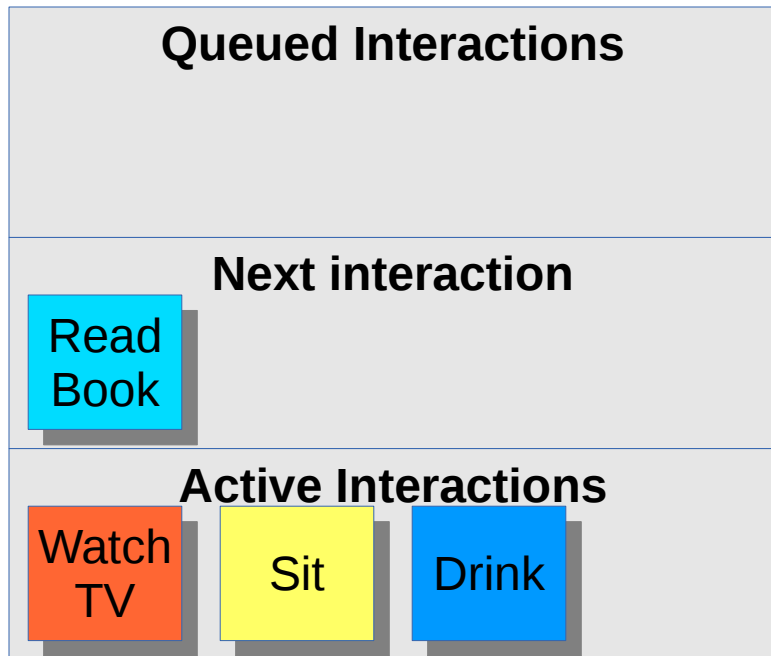
Where	How	Hands
On Seat	Sit	Hold Drink

Interaction Processing Example



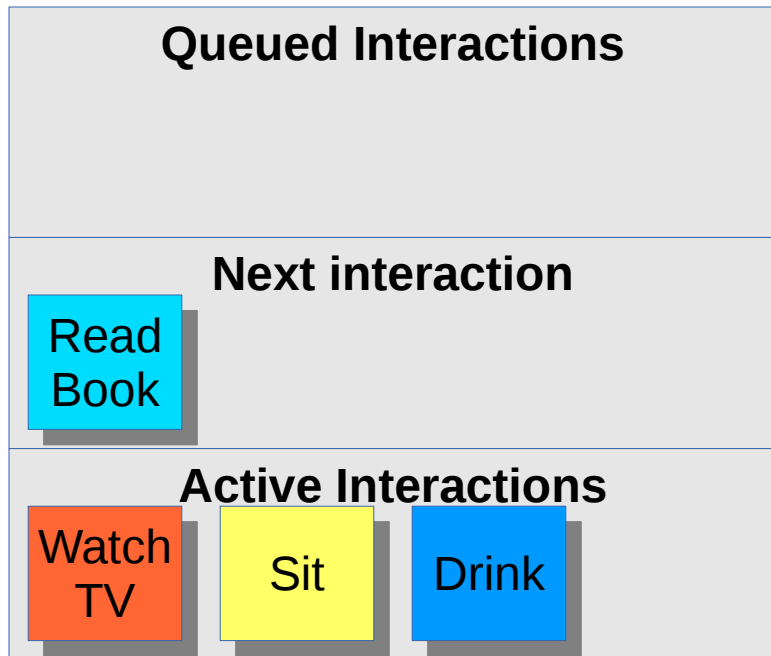
Where	How	Hands
Anywhere		
On Seat	Sit	Hold Drink

Interaction Processing Example



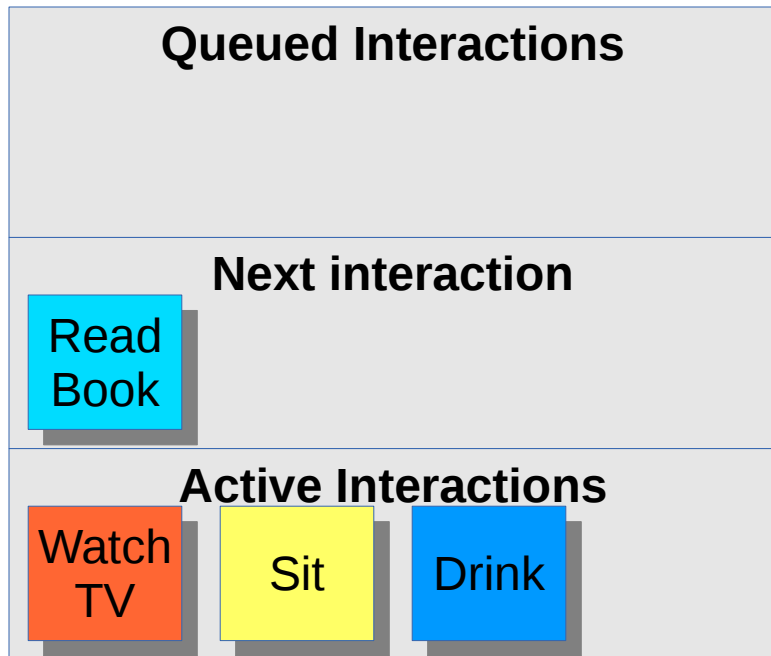
Where	How	Hands
Anywhere		
On Seat	Sit	Hold Drink

Interaction Processing Example



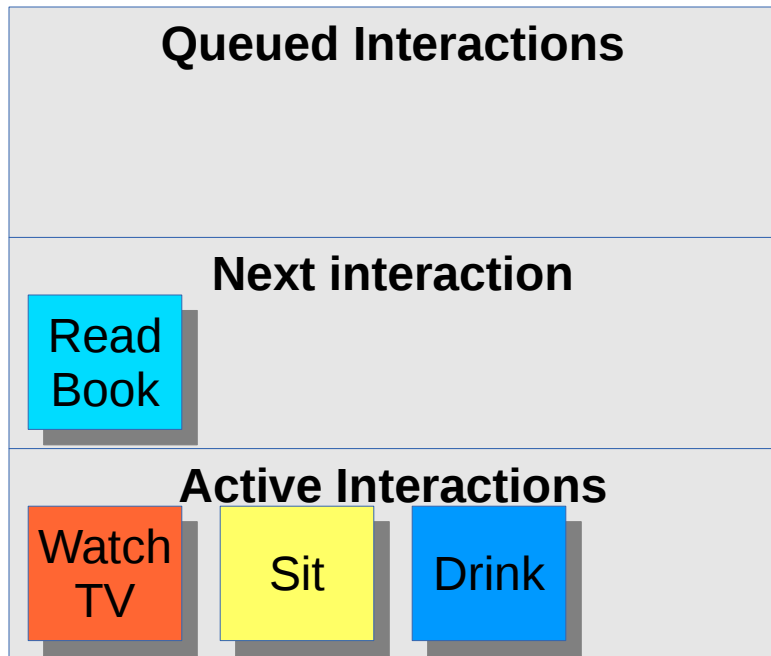
Where	How	Hands
Anywhere	Sit or Stand, Not TV	
On Seat	Sit	Hold Drink

Interaction Processing Example



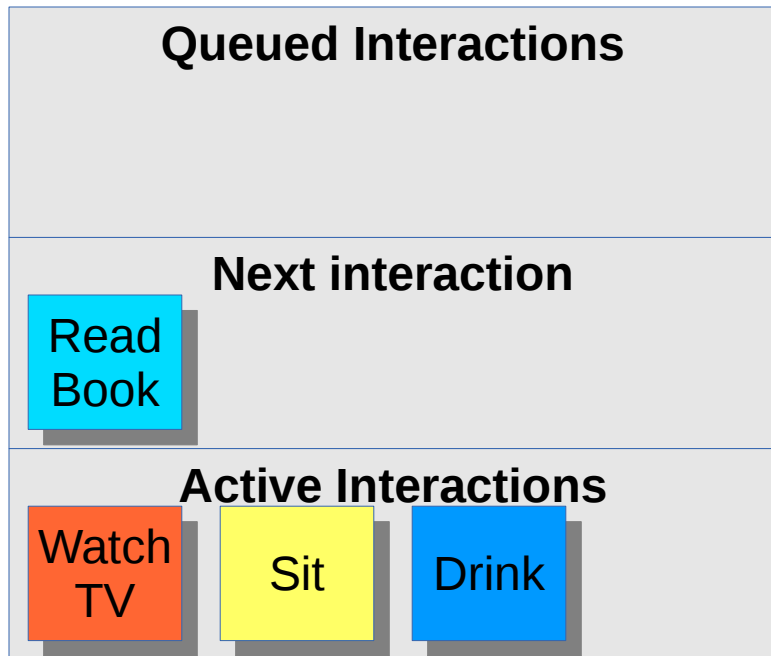
Where	How	Hands
Anywhere	Sit or Stand, Not TV	
On Seat	Sit	Hold Drink

Interaction Processing Example



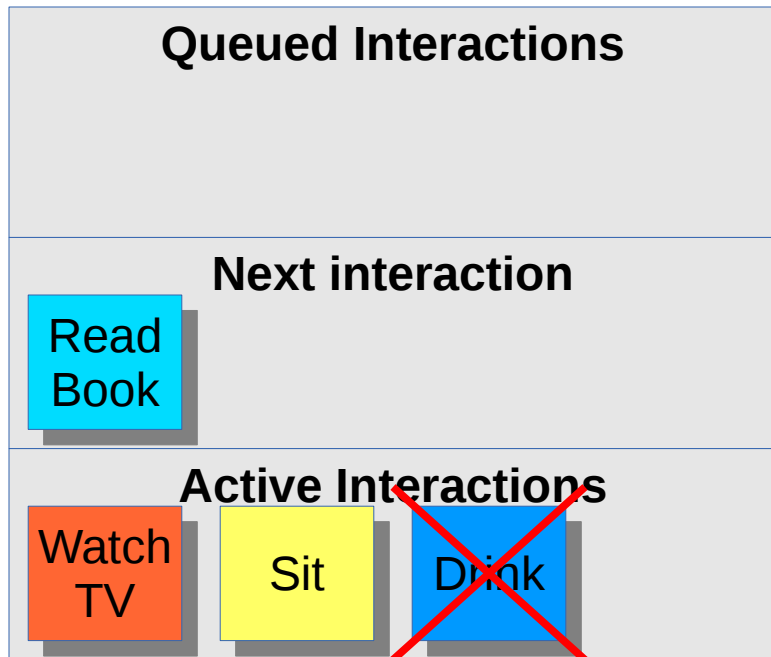
Where	How	Hands
Anywhere	Sit or Stand, Not TV	Both Hands
On Seat	Sit	Hold Drink

Interaction Processing Example



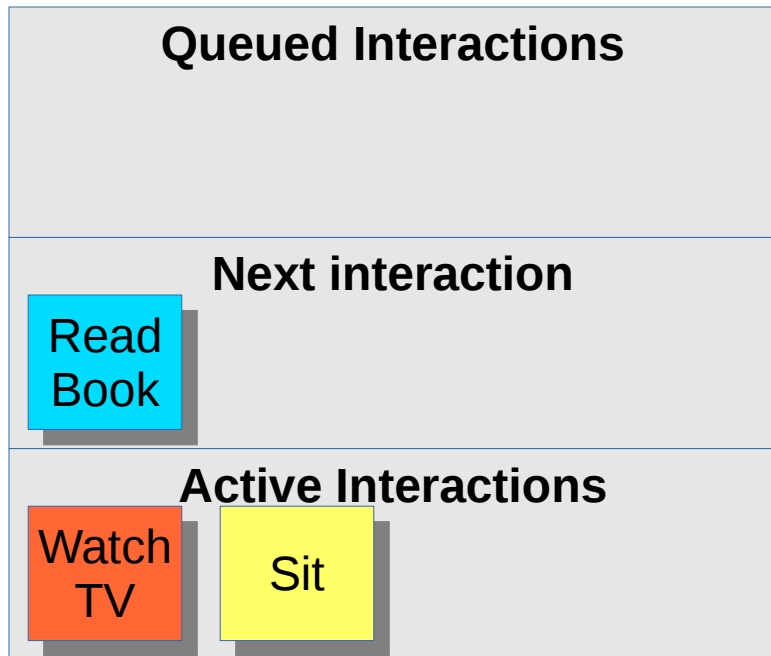
Where	How	Hands
Anywhere	Sit or Stand, Not TV	Both Hands
On Seat	Sit	Hold Drink

Interaction Processing Example



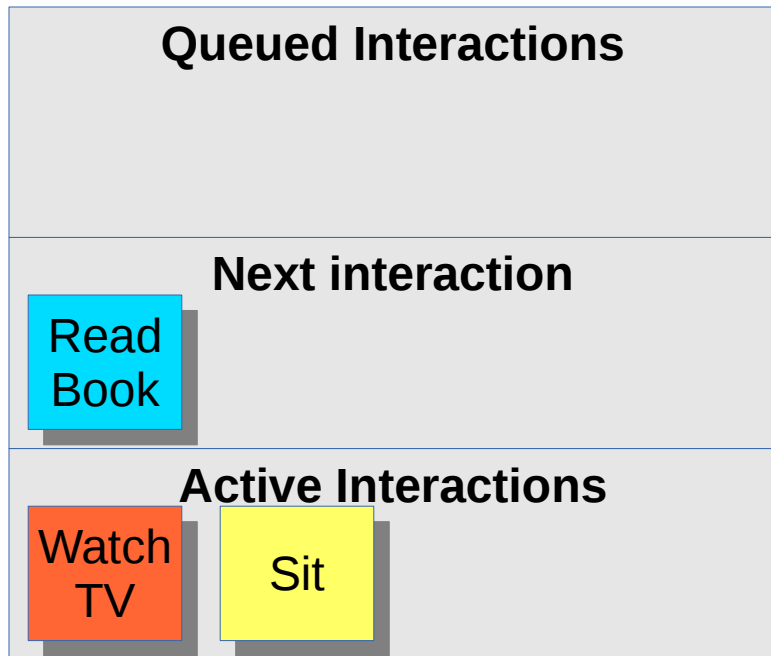
Where	How	Hands
Anywhere	Sit or Stand, Not TV	Both Hands
On Seat	Sit	Hold Drink

Interaction Processing Example



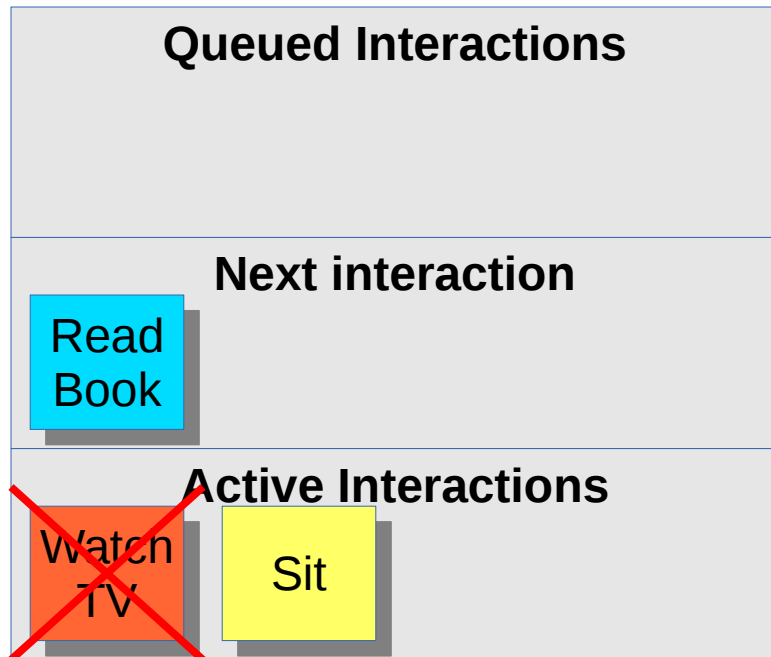
Where	How	Hands
Anywhere	Sit or Stand, Not TV	Both Hands
On Seat	Sit	Don't Care

Interaction Processing Example



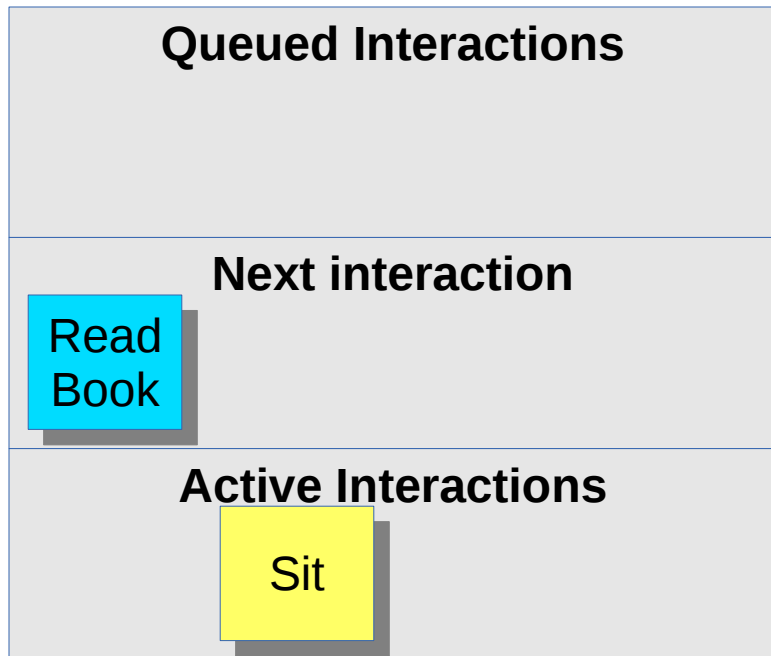
Where	How	Hands
Anywhere	Sit or Stand, Not TV	Both Hands
On Seat	Sit	Don't Care

Interaction Processing Example



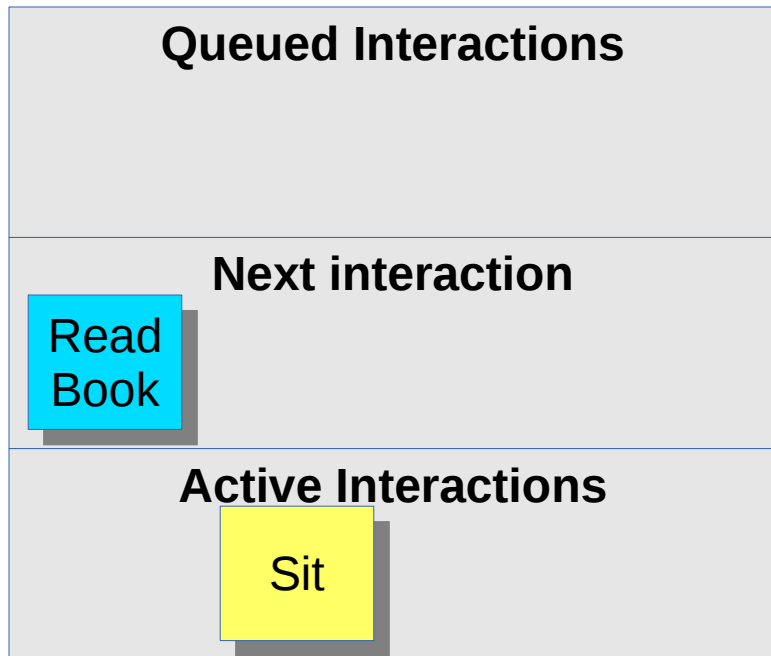
Where	How	Hands
Anywhere	Sit or Stand, Not TV	Both Hands
On Seat	Sit	Don't Care

Interaction Processing Example



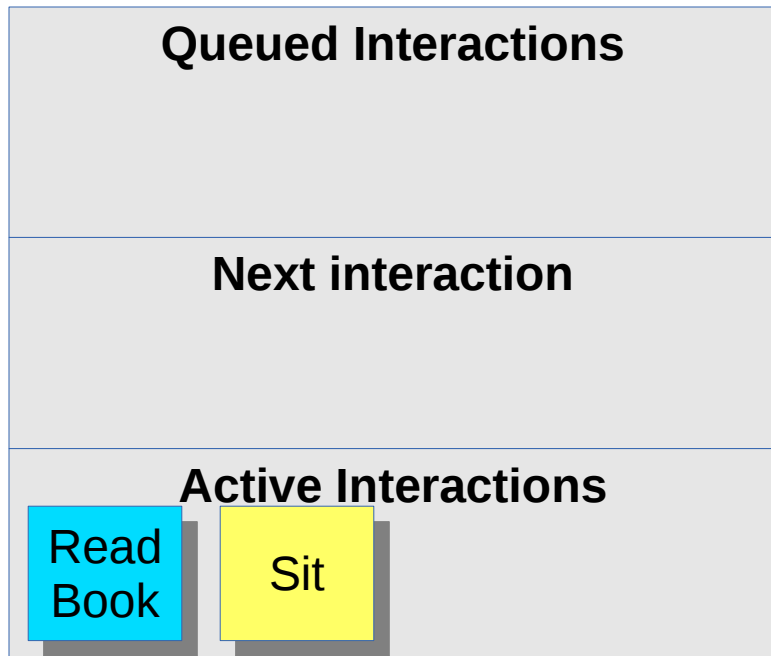
Where	How	Hands
Anywhere	Sit or Stand, Not TV	Both Hands
On Seat	Sit	Don't Care

Interaction Processing Example



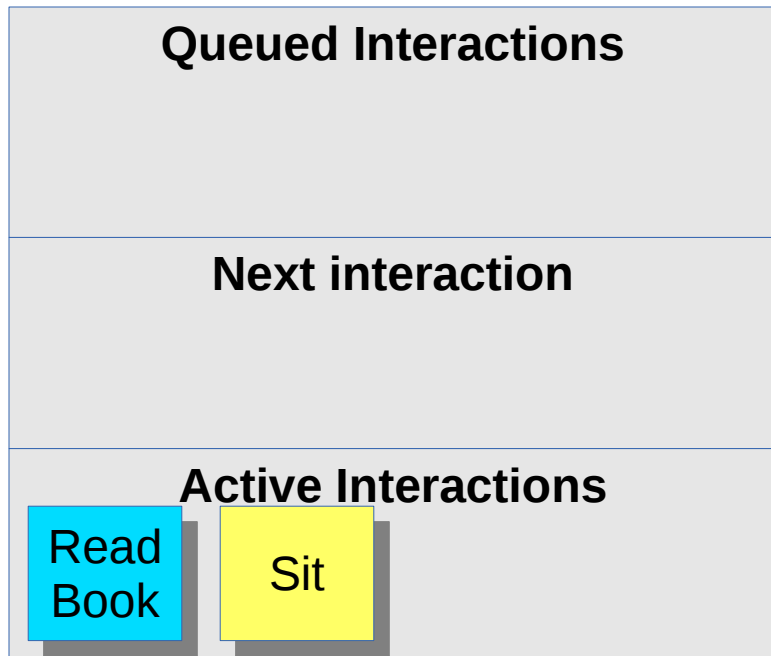
Where	How	Hands
Anywhere	Sit or Stand, Not TV	Both Hands
On Seat	Sit	Don't Care

Interaction Processing Example



Where	How	Hands
On Seat	Sit, Not TV	Both Hands

Interaction Processing Example



Where	How	Hands
On Seat	Sit, Not TV	Both Hands







Transitions

Generating Behavior

- Constraints define preconditions for performing an interaction

Generating Behavior

- Constraints define preconditions for performing an interaction
- Can be used generatively

Generating Behavior

- Constraints define preconditions for performing an interaction
- Can be used generatively
- Requires ability to find transition to constraint

Transition Graph

- The constraints on each object are stored in an abstract graph

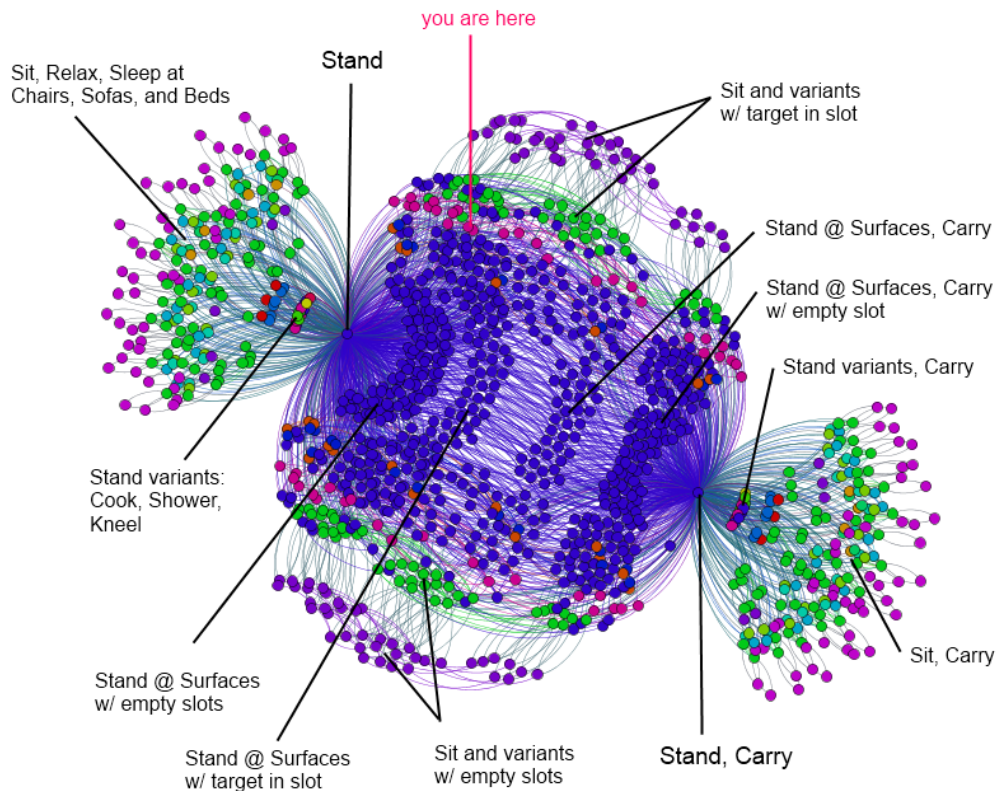
Transition Graph

- The constraints on each object are stored in an abstract graph
- Edges are state changes

Transition Graph

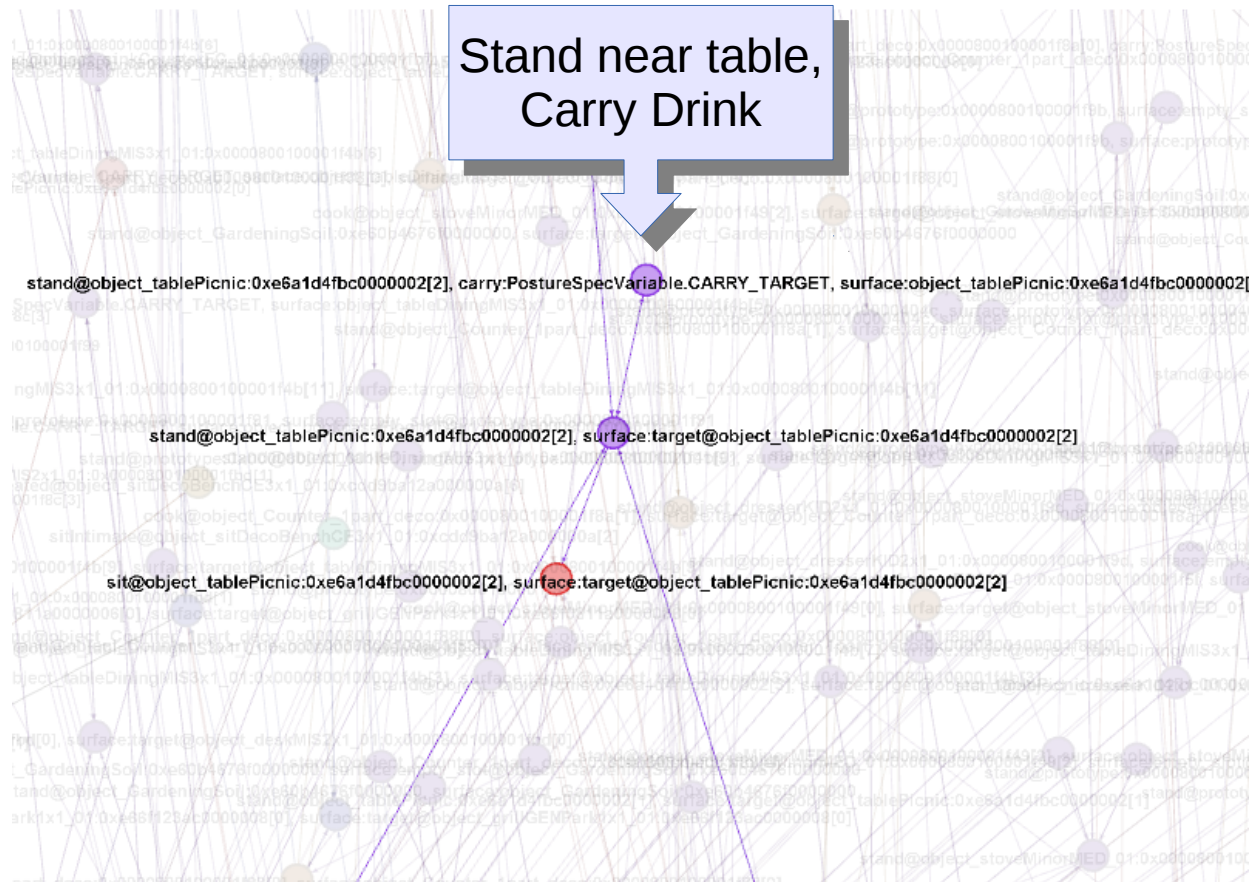
- The constraints on each object are stored in an abstract graph
- Edges are state changes
- Search graph to generate a transition sequence

Transition Graph

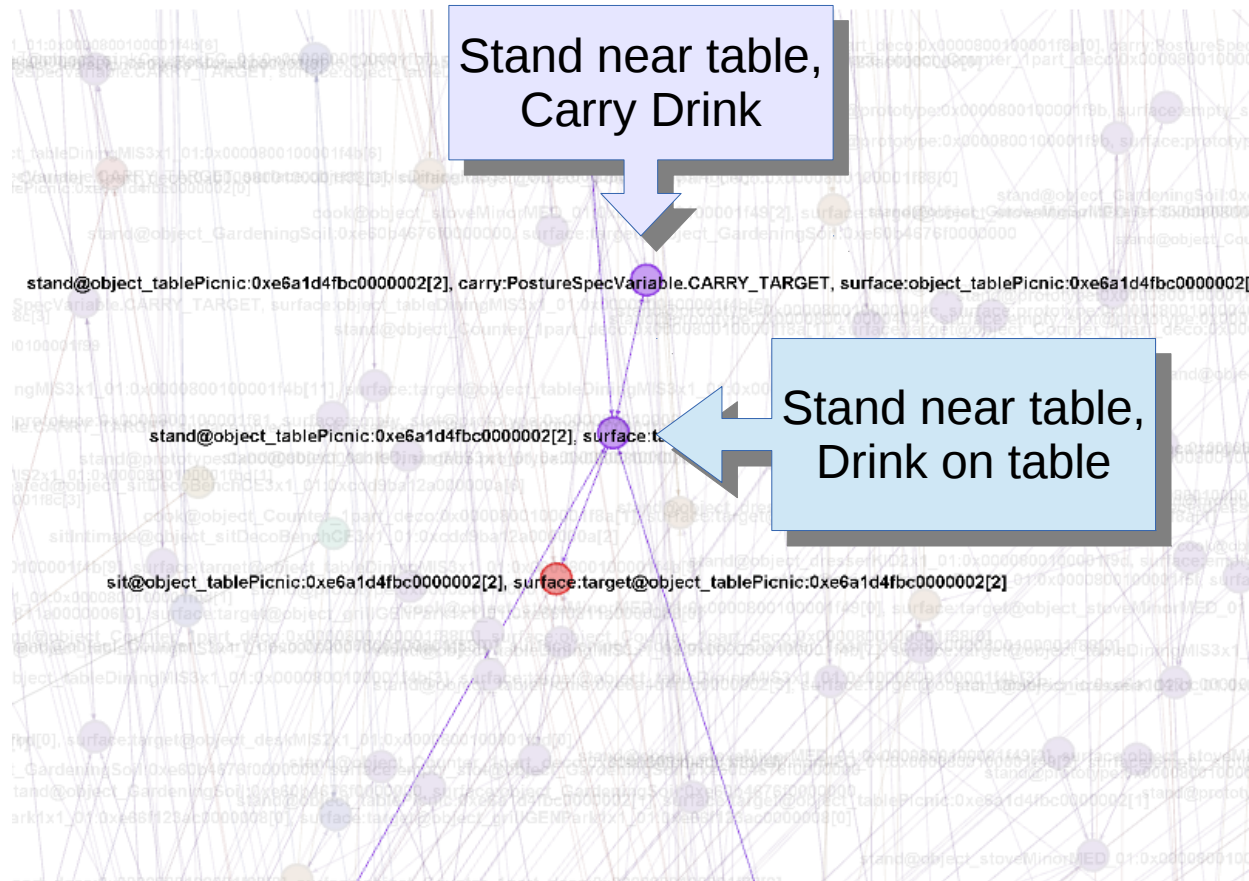


Using the Graph

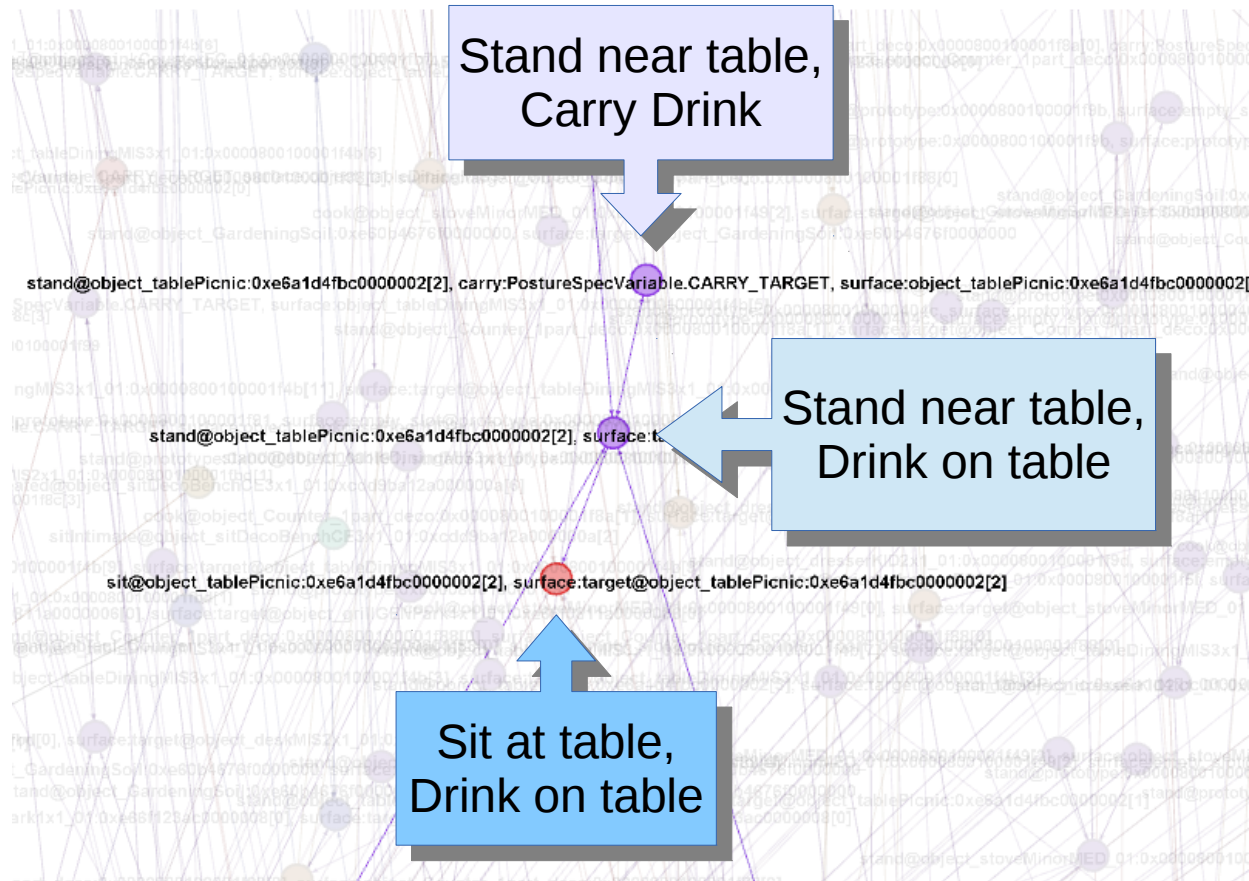
Stand near table,
Carry Drink



Using the Graph



Using the Graph



Graph Searching

- Multiple nodes can match requirements

Graph Searching

- Multiple nodes can match requirements
- Edges are weighted by cost
 - Routes weighted by approximate distance

Graph Searching

- Multiple nodes can match requirements
- Edges are weighted by cost
 - Routes weighted by approximate distance
- Search determines optimal path

Example

Carry
Transference



Example

Carry
Transference



Search Optimizations

- Bidirectional search

Search Optimizations

- Bidirectional search
- Simplifications
 - Carry
 - Slot

Search Optimizations

- Bidirectional search
- Simplifications
 - Carry
 - Slot
- Node query indexing



Socials

Socials



Socials



Socials

Intersected with
TV constraint



Socials

Intersected with
TV constraint



Convex LOS



Social Clustering



Social Clustering



Challenges – Complexity

- Building Features

Challenges – Complexity

- Building Features
 - Less tolerance for ad-hoc implementation

Challenges – Complexity

- Building Features
 - Less tolerance for ad-hoc implementation
 - Must express features using constraints

Challenges – Complexity

- Building Features
 - Less tolerance for ad-hoc implementation
 - Must express features using constraints
- Authoring content

Challenges – Complexity

- Building Features
 - Less tolerance for ad-hoc implementation
 - Must express features using constraints
- Authoring content
- Complexity of data

Challenges – Player Expectations

- Excessive multitasking

Challenges – Player Expectations

- Excessive multitasking
- Communicating compatibility

Challenges – Player Expectations

- Excessive multitasking
- Communicating compatibility
- Uncanny valley

Takeaway

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- Composable rules are necessary to support multitasking

Impact

- The spatial relationship between objects is more important

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- More diverse behavior with the same amount of content

Questions?



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Bonus Content!

Holstering



Holstering

