CSCIE97 Software Design

House Mate Controller Service Design Document

Date: 2017 October 24

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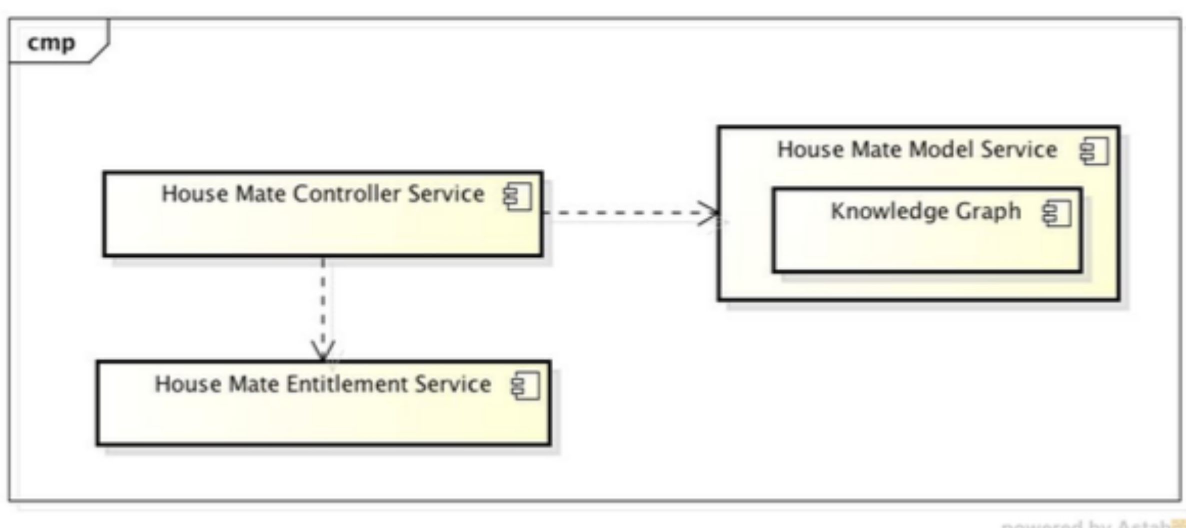
Introduction

This document defines the House Mate Controller Service design.

Overview

The House Mate home automation system is a comprehensive home automation solution; it supports multiple users with different roles in the home, allows for custom home layouts to support any living space and interfaces with myriad smart devices. The system is highly configurable, and is primarily controlled with voice commands from the home's occupants.

Here's a picture of the overall system architecture:



The subject of this document, the House Mate Controller Service, is the system component that will listen for input from sensors in the house, update the state of the system, and send any commands to smart devices as a result of the inputs.

The House Mate Controller Service will communicate with the House Mate Model service to query and update state in the House Mate System. As detailed in my House Mate Model Service design document, the modeled classes in the system are:

- House
- Room
- Occupant
- Devices
  - “Appliances”, that have settings/commands
  - “Sensors” that measure/detect the environment
- Measures - Device features that provide environmental status and state
- Settings - Device features that control the behavior of the device

The controller service will be loaded with “Rules” and “Commands”. Rules will match incoming sensor data (Measures) to see what types of “Commands” might need to be taken.

When a rule is matched, the Controller service may then update the state of “Settings” and “Measures” in the House Mate Model Service to capture the new state of the system.

Settings are properties of smart appliances that, when changed, constitute a physical state change on the actual appliance. For example, a light device may have a “dimness” setting, which, when changed will issue a command to the light to change it’s dimness.

Measures are inputs from smart sensors that will be matched against “Rules” registered in the controller that will update the state of the system in pre-defined ways.

Consider the following: a modeled Ava device might have a Measure called “voice_command” which accepts arbitrary string values. When somebody speaks to Ava, the phrase they utter will be the current value of the “voice_command” Measure. If the controller detects a ‘voice_command’ from Ava which matches a rule, that rule will update the system state via the House Mate Model Service. If the state changes represent a change to the Setting of one of the smart devices, that will manifest as a ‘command’ to be sent to the smart appliance whose Setting was changed.

For example:
Somebody in the kitchen says: “Turn on the ceiling fan”

This might be passed to the controller as:
set sensor House:Kitchen:Ava state voice_command value “Turn on the ceiling fan”
If the controller understands that phrase, a rule will be matched and it will query and update the state of the model:

First it might issue this command to the House Mate Model Service:

```
show House:Room:Kitchen
```

to see if there are any ceiling fan devices registered in the kitchen.

If it finds one, It might issue:

```
set appliance House:Room:Kitchen:CeilingFan status power_mode
value ON
```

And

```
set appliance House:Room:Kitchen:Ava status voice_command value
Turn_On_The_Ceiling_Fan
```

The first command will update the ceiling fan power_mode Setting, and the second command will store a new value for the voice_command Measure, in case the next detected voice_command is something like “Cancel the last command”.

If either of the calls to House Mate Model Service fails, appropriate exception handling will take place - but if they succeed, the controller may then invoke a registered “Action” for the device acting as the receiver of the command. In this case, the Ceiling Fan in the kitchen.

Let’s say there is no ceiling fan in the kitchen; the controller may then issue this command to the HMMS:

```
set appliance House:Room:Kitchen:Ava status voice_response value
“There is no ceiling fan in the kitchen. Did you mean another
room?”
```

This will update the “voice_response” Setting of the Ava appliance, and likely invoke an action to “Speak voice_response” on the device so the Occupant can hear the feedback.

The document that follows will detail the requirements, use cases, and Implementation design that will be used to create the Controller Service. It will include diagrams where helpful, including Activity and Class diagrams to support the Implementation section. There will also be sections describing the testing framework as the Risks associated with this draft of the design.

Requirements

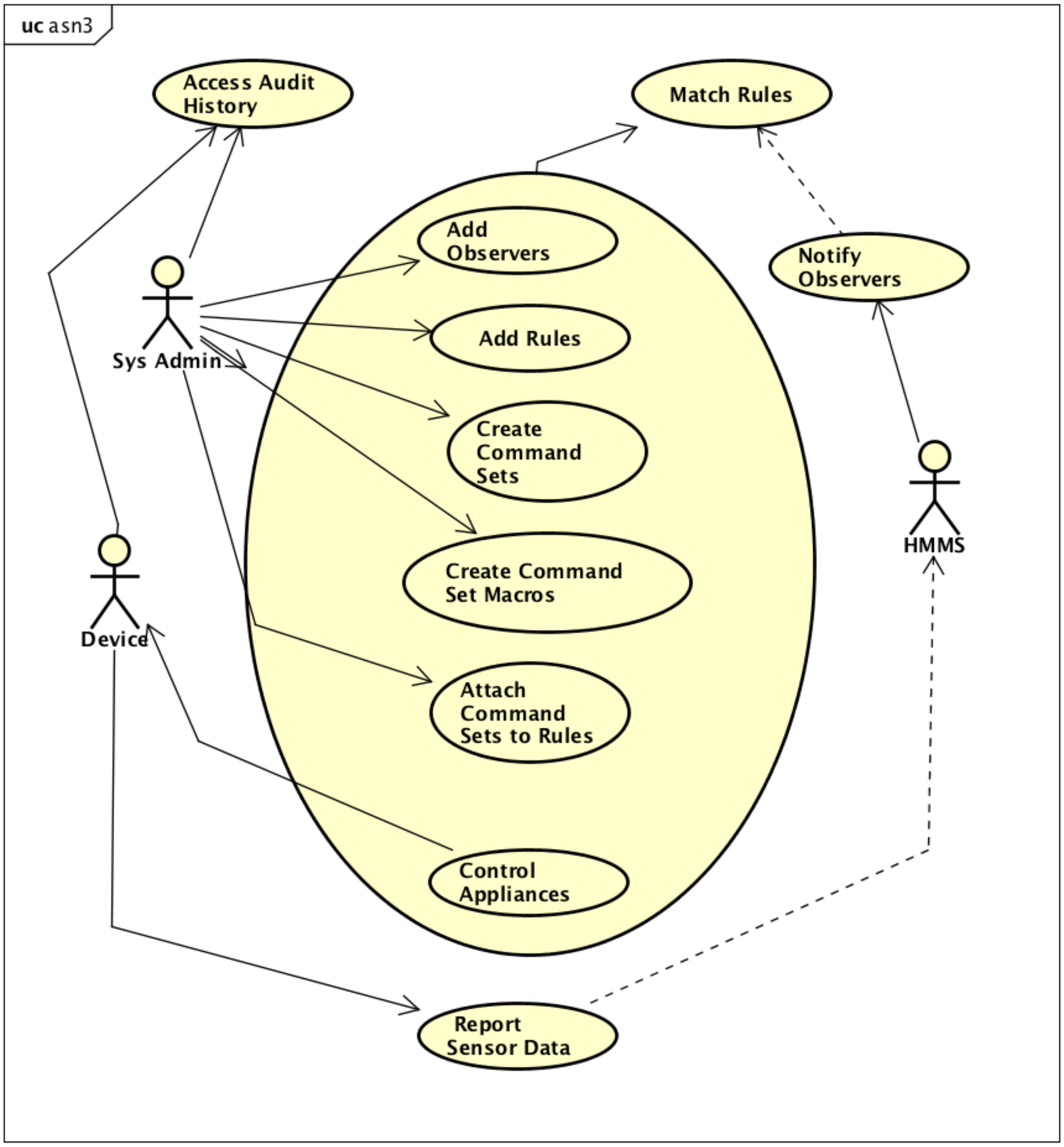
Generally, the House Mate Controller Service is to listen for inputs from smart Devices that are part of the system and apply actions which will change the state accordingly. These state changes may invoke ‘Actions’ or ‘Commands’ that change the physical state of system appliances.

More specifically, it will:

- Support the creation of “Commands” that will change the state of the system, and invoke physical changes in appliances.
    - A single command can affect more than 1 appliance at a time
- Support the creation of “Rules” that will interpret incoming sensor data, and invoke 1 or more Commands.
    - Rules can be matched based on incoming sensor data or by system-invoked state changes
    - Rules will have one ore more ‘predicates’ that can be used to determine whether to invoke the associated Commands
    - Rules can invoke more than one Command
    - The actions a rule invokes can trigger a match on more rules that trigger more actions.
- Allow for Rules to Observe incoming sensor information/model state changes, including, but not limited to:

  - Voice commands from intelligent ‘speakers’, like Ava, Google Home, Apple HomePod and the new Sonos speaker.
  - Video signals from cameras, and more specifically motion and facial recognition signals
  - Environmental sensor information like decibels, temperature, brightness, humidity, pressure, smoke and pollutants, water/moisture and more
- It will log activity in the system, including:
  - All incoming sensor data
  - All matched rules
  - All invoked actions
  - All state changes resulting from actions
- Can be extended to potentially allow for reversal of actions (undo)
- Will communicate exclusively with the House Mate Model Service to read and write system state.

Use Cases



uc asn3
Access Audit History
Match Rules
Add Observers
Notify Observers
Sys Admin
Add Rules
Create Command Sets
HMMS
Create Command Set Macros
Device
Attach Command Sets to Rules
Control Appliances
Report Sensor Data

Use Case Detail

Detect Sensor Information

- Preconditions: The House Mate Model Service (HMMS) has a configuration loaded which includes Devices (Sensors and/or Appliances with sensors)
- Smart sensors throughout the home send data to the House Mate system. The devices are configured to send data directly to the HMMS. The values provided by the sensors represent the ‘facts’ of the system, and they are not subject to interpretation. Here’s the basic flow:
  - The HMMS is configured to add a certain device.
  - That device is configured with the features (Measures and Settings) it supports
  - As the device collects data, it sends the data directly to the HMMS using the HM command interpreter or the HMMS API

Observe Devices

- Precondition: The House Mate Model Service (HMMS) has a configuration loaded which includes Devices (Sensors and/or Appliances with sensors)
- A system admin or device manufacturer determines a ‘Feature’ of interest in one of the available sensor devices (i.e., “I’m interested in whenever the relative humidity changes), and registers an observer function for that feature. A “Feature” in this case is specific measure on a specific device. (For example, the relative humidity measurement of the barometer in the basement). When the Feature changes state, the defined observer function is executed. A device manufacture may provide a ‘bootstrap script’ or a ‘jar file’ or some other sort of archived set of observer functions, while a sys admin may want to add observers on an ad-hoc basis.
- If the Feature doesn’t exist (i.e. there is no barometer in the basement), an error will be returned from the registration request.
- A possible extension would be to register a single observer function for all Features that provide the same measurement: for example, registering a single observer function for all “Temperature” changes in the house - regardless of what device they came from.

Define rules

- Preconditions: Device Observers have been registered in the system
- A system admin or device manufacture defines a ‘rule’ associated with an observer function. An observer could possible have multiple rules associated with it. A rule will

likely apply some conditional checks about the current ‘facts’ present in the observation, like “is this observation within some range” or “does this observation include a voice_command with a known pattern”? It’s also possible that the rule will match every time a device observation is made, regardless of its value or measurement.

Define Reusable Commands Sets

- Preconditions: A command language or plug-in architecture is available.
- A device manufacturer or System Admin can create command sets (consisting of one or more commands) that can be attached to rules. As noted, a command set can be as little as 1 command. These command sets are meant to be ‘reusable’ across rules - for example, a command set might turn off the lights and lower the temperature in a room. We may want to execute that command set either when everybody leaves the room or when its determined that somebody has fallen asleep on the couch.

Define macro command sets

- Prerequisites: Command sets exists
- Effectively, a command set of command sets. A system admin or device manufacturer can organize existing command sets into bigger command sets with more functionality.
- Possible extension will allow an arbitrary number of nested command sets.

Attach/Detach command sets to rules

- Preconditions: Rules have been defined
- A device manufacturer or System Admin can associate command sets with matched rules. If the command set no longer makes sense for a particular rule, it can be removed from the rule.

Match Rules and Execute Commands

- When a rule is matched, the controller will execute the defined command sets within the rule. Keep in mind that a command will likely change state, which could trigger more rules which could execute more command sets, which could lead to circular execution. The controller must be responsible for detecting and handling circular command execution loops.
- Specifically, we may want to listen for a certain voice command and then update an associated device. For example a voice command of “Dim Lights” should dim the lights in the room where the voice command was issued.

Send Commands to appliances

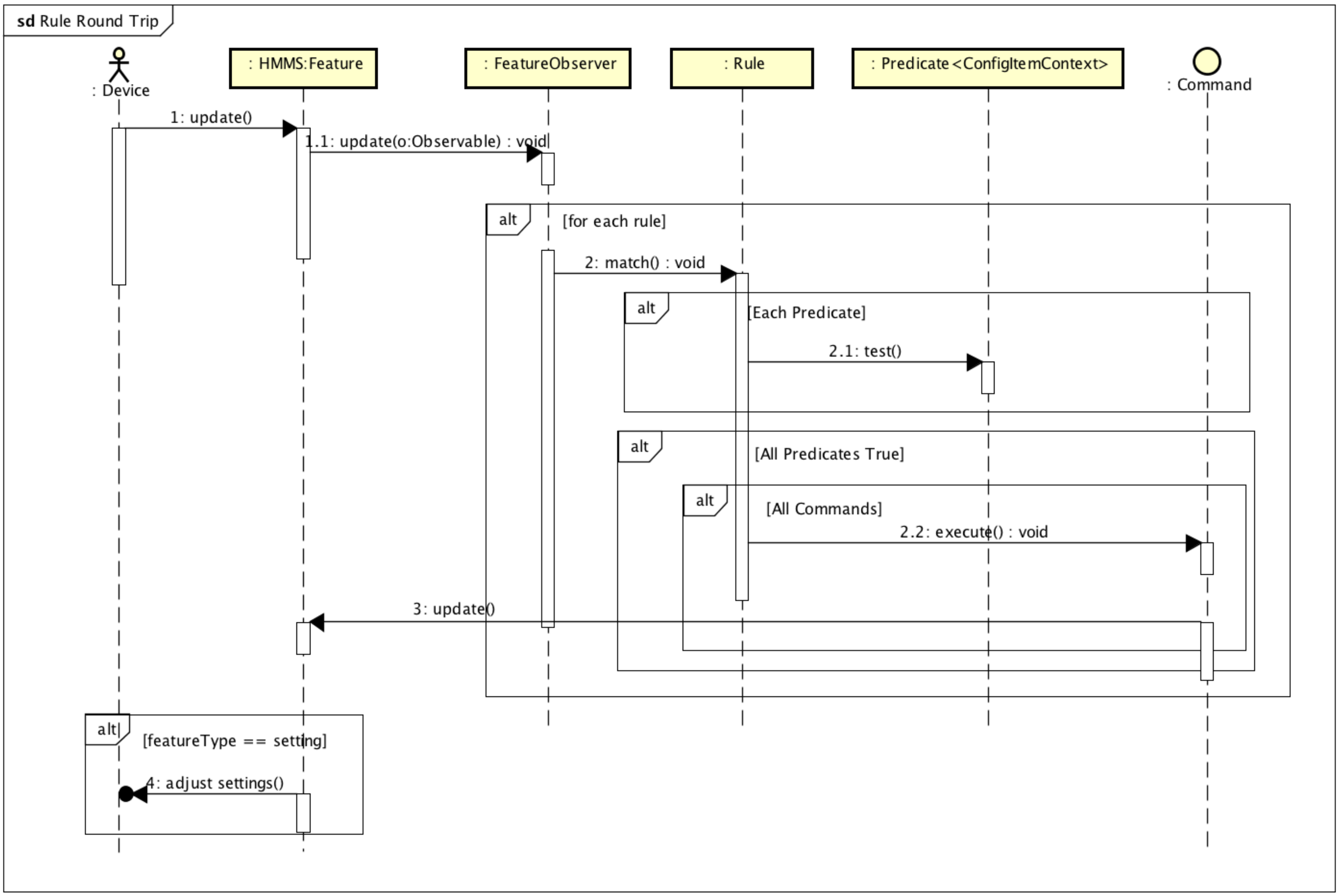
- As part of the command executions, the controller may update appliance state - which will materialize as a 'command' sent to an appliance. This will be the 'tangible-manifestation' of the automated home from the occupant's perspective.

Audit System History

- Prerequisites: The system is activated and activity has taken place
- A system admin or device has access to the history of activity in the system. Initially this will include
  - A history of all configuration changes
  - A log of registered rules and commands
  - A log of all device state changes
  - A history of all occupant history
- This will be used for troubleshooting, status reporting, investigation, and possibly for the support of 'undoable' actions.
- Possible extension: It can also be used to 'reset' the state of the system in case of power outage or other system failure.

Sequence Diagrams

This diagram illustrates an “Update -> Rule -> Command” round trip. The classes represented here are described in more detail in the Implementation section.



Implementation

The key constructs in the controller are:

- Rules
- Predicates
- Contexts
- Commands

In more detail:

Rules are attached as observers to Features in the HouseMateModel, and when the observed Feature is updated all attached rules are "Matched".

Contexts are attached to Rules, and provide the data elements that will be tested by predicates.

Predicates are attached to Rules. Predicates are simple tests against a set of data. For example: "Are the lights currently on? Is anybody in this room?"

When a rule's match() method is called, all predicates are provided with the rule's contexts, and tested. If all predicates test positive, then…

Commands that are attached to the rule are executed. Commands are passed an Invoker object which will maintain its own context. In concrete terms, the Rule object is the Invoker and it has "Context" that can be used by the Command). The commands will maintain the target of the command (for example a device feature) as well as a value to pass to the target. Sometimes that value will be derived from the context available in the Invoker.

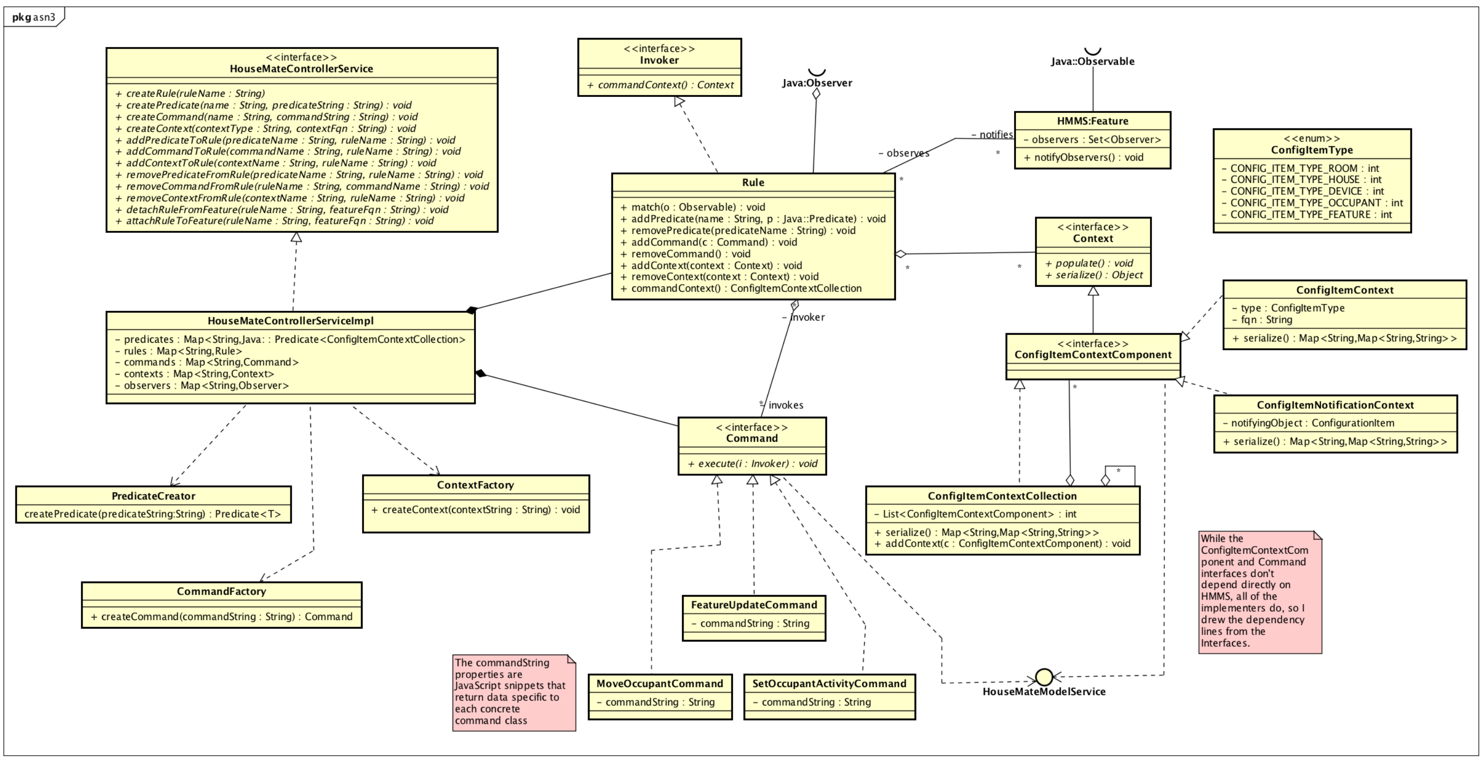
The diagrams and class dictionary that follow provide detail on these concepts.

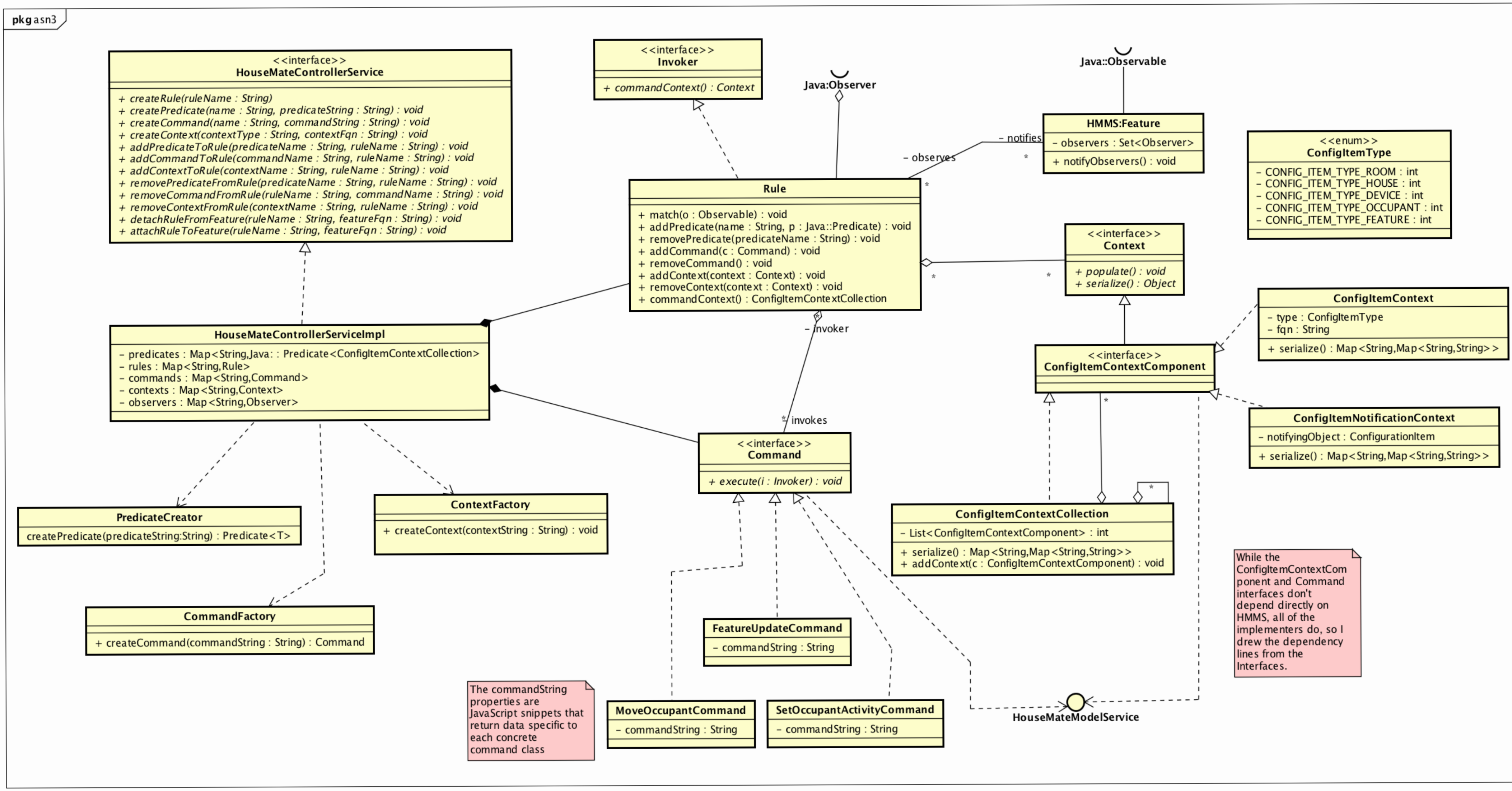
On top of these Model constructs will be an API which will allow for creating and associating these model constructs.

The API will meet the requirements of the system by:

- Creating Rules, Commands, Predicates and Contexts
- Associating Commands, Predicates and Contexts to rules.

Class Diagram




pkg asn3
<<interface>>
HouseMateControllerService
+ createRule(ruleName : String)
+ createPredicate(name : String, predicateString : String) : void
+ createCommand(name : String, commandString : String) : void
+ createContext(contextType : String, contextFqn : String) : void
+ addPredicateToRule(predicateName : String, ruleName : String) : void
+ addCommandToRule(commandName : String, ruleName : String) : void
+ addContextToRule(contextName : String, ruleName : String) : void
+ removePredicateFromRule(predicateName : String, ruleName : String) : void
+ removeCommandFromRule(ruleName : String, commandName : String) : void
+ removeContextFromRule(contextName : String, ruleName : String) : void
+ detachRuleFromFeature(ruleName : String, featureFqn : String) : void
+ attachRuleToFeature(ruleName : String, featureFqn : String) : void
<<interface>>
Invoker
+ commandContext() : Context
Java:Observer
Java::Observable
HMMS:Feature
- observers : Set<Observer>
+ notifyObservers() : void
- notifies
- observes
<<enum>>
ConfigItemType
- CONFIG_ITEM_TYPE_ROOM : int
- CONFIG_ITEM_TYPE_HOUSE : int
- CONFIG_ITEM_TYPE_DEVICE : int
- CONFIG_ITEM_TYPE_OCCUPANT : int
- CONFIG_ITEM_TYPE_FEATURE : int
Rule
+ match(o : Observable) : void
+ addPredicate(name : String, p : Java::Predicate) : void
+ removePredicate(predicateName : String) : void
+ addCommand(c : Command) : void
+ removeCommand() : void
+ addContext(context : Context) : void
+ removeContext(context : Context) : void
+ commandContext() : ConfigItemContextCollection
<<interface>>
Context
+ populate() : void
+ serialize() : Object
ConfigItemContext
- type : ConfigItemType
- fqn : String
+ serialize() : Map<String,Map<String,String>>
<<interface>>
ConfigItemContextComponent
HouseMateControllerServiceImpl
- predicates : Map<String,Java: : Predicate<ConfigItemContextCollection>
- rules : Map<String,Rule>
- commands : Map<String,Command>
- contexts : Map<String,Context>
- observers : Map<String,Observer>
- invoker
invokes
<<interface>>
Command
+ execute(i : Invoker) : void
ConfigItemNotificationContext
- notifyingObject : ConfigurationItem
+ serialize() : Map<String,Map<String,String>>
PredicateCreator
createPredicate(predicateString:String) : Predicate<T>
ContextFactory
+ createContext(contextString : String) : void
ConfigItemContextCollection
- List<ConfigItemContextComponent> : int
+ serialize() : Map<String,Map<String,String>>
+ addContext(c : ConfigItemContextComponent) : void
While the ConfigItemContextComponent and Command interfaces don't depend directly on HMMS, all of the implementers do, so I drew the dependency lines from the Interfaces.
CommandFactory
+ createCommand(commandString : String) : Command
FeatureUpdateCommand
- commandString : String
The commandString properties are JavaScript snippets that return data specific to each concrete command class
MoveOccupantCommand
- commandString : String
SetOccupantActivityCommand
- commandString : String
HouseMateModelService

Class Dictionary

Interface::HouseMateControllerService

Interface

Public API that allows access to the House Mate Controller Service. All operations will require an auth token, and throw "UnauthorizedException" if an invalid token is passed for the requested API call.

Operations		
Operation	**Description**	**Throws**
public **createObserver**(observerName : String, featureFqn : String) : void	Adds an observer to a Feature in the House Mate Model.	ItemNotFoundException UnauthorizedException
public **createRule**(ruleName : String)	Creates a Rule that can be attached to an observer. Predicates, Context and Commands will be attached to a rule. Adds created rule to the managed collection of Rules.	ItemExistsException UnauthorizedException
public **createPredicate**(name : String, predicateString : String) : void	Creates a Predicate and adds it to the collection of predicates. A predicate is a snippet of code that will test a condition in for a given context. The predicates will be attached to rules, and tested based on the context associated wit that rule. The predicate string can be any snippet of code that is supported by the Predicate Factory. Initially, the only supported predicate string type will be snippets of JavaScript that will accept ConfigItemContext objects as their parameters.	InvalidPredicateString ItemExistsException UnauthorizedException

Operations		
Operation	**Description**	**Throws**
public **createCommand**(name : String, commandString : String) : void	Adds a Command to the controller. The commandString is a valid command string that will be supported by the Command Factory to create a command. The commands are attached to Rules and executed when all Predicates attached to the rule are true. Initially, the only supported command string type will be HouseMateModelService::CommandInterpreter command strings.	InvalidCommandString ItemExistsException ImportException UnauthorizedException
public **createPredicate**(name: String, predicateString: String) void	Adds a predicate to the system	
public **createContext**(contextType : String, contextString : String) : void	Creates a context and adds to the context collection. Contexts are added to Rules to provide facts to the Predicates. The Context object created will have a getContext() method that will return facts that can be used by predicates. The contextString can be any string that the ContextFactory knows how to produce. The contextString could be a “sql” query or a webservice URL. In the HMCS, the context objects will use HMMS FQNs to find facts in the KnowledgeGraph that will be assessed by the predicates to determine whether system state dictates further action. Initially, the only valid contextString will be a House Mate Model FQN.	InvalidContextString ItemNotFoundException ImportException UnauthorizedException
public **addPredicateToRule**(predicateName : String, ruleName : String) : void	Attaches a Predicate to a Rule so that the predicate.test() will be called during the Rules match routine. All attached predicates will be tested.	ItemNotFoundException UnauthorizedException

Operations		
Operation	**Description**	**Throws**
public **addCommandToRule**(commandName : String, ruleName:String) : void	Adds a Command to a Rule. If all predicates are true in a rule, ALL attached commands will be executed.	ItemNotFoundException UnauthorizedException
public **addContextToRule**(contextName : String, ruleName : String) : void	Adds a Context object to a Rule. The result of the Context.getContext() method will be passed to Predicates as facts to test the Predicates against.	ItemNotFoundException UnauthorizedException
public **removePredicateFromRule(**predicateName : String, ruleName : String) : void	Removes a Predicate from a rule.	ItemNotFoundException UnauthorizedException
public **removeCommandFromRule**(ruleName : String, commandName : String) : void	Removes a command from a rule.	ItemNotFoundException UnauthorizedException
public **removeContextFromRule**(contextName : String, ruleName : String) : void	Removes a context from a rule.	ItemNotFoundException UnauthorizedException
public **attachRuleToFeature**(ruleName : String, featureFqn : String) : void	Attaches a Rule to a feature. ruleName is the name passed in when using createRule, and featureFqn is the fully qualified name of an HMMS Feature object.	ItemNotFoundException UnauthorizedException
public **detachRuleFromFeature**(ruleName : String, featureFqn : String) : void	Detaches the rule as an observer of a Feature. ruleName is the name passed in when using createRule, and featureFqn is the fully qualified name of an HMMS Feature object.	ItemNotFoundException UnauthorizedException

Class::HouseMateControllerServiceImpl

Implements Interface::HouseMateControllerService

This is an insecure implementation that expects an auth parameter of “1” to authorize all API calls.

Other than implementing the public API, this class has the following:

Associations		
Association	**Type**	**Description**
observers	Map<String, Observer>	The observers registered in the Controller
rules	Map<String, Rule>	The list of occupants associated with the service
commands	Map<String,Command>	The list of commands available in the controller.
contexts	Map<String,Context<T>>	The list of context available in the controller.
predicates	Map<String,Predicate>	The list of predicates available in the controller.

Interface::Invoker

Represents an 'Invoker' of a command. The "Command::execute()" method will take an Invoker as a parameter. Invokers implement 1 method "commandContext()", which will return an object that implements Context, so the command can have some data if the invoker chooses to provide some. The commandContext() provides House Mate state to commands in order to meet system requirements dictating that certain commands be dynamic (For example, to execute a command that updates all windows in a room where a voice_command was issued, we need to tell the command what room the occupant is in).

Operations		
Operation	**Description**	**Throws**
public **commandContext**() : Context	Returns a "Context" object (see Interface::Context) which can provide data to the invoked command.	

Class::Rule

Implements Interface::Invoker

Represents a ‘rule’ that tests system state, and given certain conditions will execute commands to update devices. Will be composed of Predicates, Contexts and Commands.

Operations		
Operation	**Description**	**Throws**
public **match**() : void	Performs the match routine, which will populate contexts, test predicates and execute commands if all predicates return true.	
public **addPredicate**(name : String, p : Predicate<T>) : void	Adds a predicate to the rule.	ItemExistsException
public **removePredicate**(predicateName : String) : void	Removes a predicate from the rule	ItemNotFoundException
public **addCommand**(c : Command) : void	Adds a command to the rule.	ItemExistsException
public **removeCommand**(commandName : String) : void	Removes a command from the rule	ItemNotFoundException
public **addContext**(context : Context) : void	Adds a context to the rule. For my tests most rules are simply passed the entire HouseMateModelContext (fetched by calling “HSSM:getAll()”. However, by adding multiple smaller contexts, the clients can compose contexts of discrete context elements. This would be desirable if the entire context stored in the HouseMate system was too large to efficiently pass between objects, or if the context was fetched from a remote service where large data took a long time to retrieve.	ItemNotFoundException
public **removeContext**(context : Context) : void	Removes a context from the rule	ItemNotFoundException UnauthorizedException

Operations		
Operation	**Description**	**Throws**
public **commandContext**() : ConfigItemContextCollection	Override of Invoker interface method. Will return a ConfigItemsContext object when called. This way, the command that gets invoked will have all of the context of the Rule when it executes. The command context will be a map of KnowledgeGraph triples representing the state: for example: {House1:Room1={has_occupant_count =3, has_window_count=4}, House1:Room1:Ava:Setting:text_to_sp eech={is_set_to='some value'}}. See the ConfigItemContextCollection dictionary entry for more information.	

Associations		
Association	**Type**	**Description**
contexts	Map<String, Context>	The list of contexts associated with the rule
predicates	Map<String, Predicate>	The list of predicates associated with the rule
commands	Map<String,Command>	The list of commands associated with the rule

Interface::Command

A command interface, exposing a single method: execute().

Operations		
Operation	**Description**	**Throws**
public **execute**(i : Invoker) : void	Called to execute the command. Actual command behavior will be defined by implemented by the implementors. Takes an Invoker object as a parameter so the invoker's commandContext() method can be called to possible inform the execution behavior.	ItemNotFoundException
public getCommandId(s: String) void	Returns the commandId. Implemented by subtypes	

Class::FeatureUpdateCommand

Implements Interface::Command

This class encapsulates the data needed to perform a Feature update in the HouseMateModelService. One of these objects will be created for a command with a pre-known discrete value. For example, to create a “Turn Oven Off” command. This would be constructed with a final value of “OFF”.

Class::FeatureUpdateCommand - Continued

Attributes		
Attribute	**Description**	**Throws**

- commandString : String	A javascript snippet that returns an object with of the form:
	{
	    targetDeviceScope: “some_fqn”,
	    targetDeviceState: “some_device_state”,
	    targetValue: anyValue
	}
	
	The target device scope can be any portion of an FQN. And the device state is any “FeatureFQN”. This is a dynamic construct that allows for determining at runtime, what feature should be sent to which devices. Remember, the command has the “commandContext()” that it got sent from the Invoker, so it can use that to determine what device scope and features to update. It can also use that context to dynamically determine a value. For example, this could be hard coded to something like:
	{
	    targetDeviceScope: “House:LivingRoom”,
	    targetDeviceState: “window_position”,
	    targetValue: “OPEN”
	}
	
	This would tell all devices in the living room that support a window_position feature to Open. This way, commands can be sent based on feature, and not just ‘device type’. This could be interesting, for example:
	{
	    targetDeviceScope: “House”,
	    targetDeviceState: “text_to_speech”,
	    targetValue: “Get OUT!”
	}
	
	This will tell all devices that support the ‘text_to_speech’ feature to say the phrase “Get Out!” - even if they’re not Ava devices.
	
	Also, by using the command context, you can dynamically derive the scope:
	{
	    targetDeviceScope: commandContext().roomFqn,
	    targetDeviceState: “text_to_speech”,
	    targetValue: “Get OUT!”
	}	

Operations		
Operation	**Description**	**Throws**
public **execute**(i : Invoker) : void	The execute() method will fetch the passed in Invoker's context and run the javascript to derive the update value. Once it has the scope and target state, it will run: updateFeature(deviceFqn, deviceStateFqn, value) for every in-scope device in the HouseMateModelService. This will handle most needs of the controller, in terms of meeting requirements to 'update state' in the system as a result of evaluated rules.	ItemNotFoundException

Class::MoveOccupantCommand

Implements Interface::Command

This class encapsulates the data needed to perform a moveOccupant() command in the HMMS.

<table>
<tr><th colspan="3">Attributes</th></tr>
<tr><th>Attribute</th><th>Description</th><th>Throws</th></tr>
<tr><td>- commandString : String</td><td>A javascript snippet that returns an object with of the form:
{
    occupantId: “some_occupant_id”,
    roomFqn: “some_room_fqn”
}

Like the FeatureUpdateCommand, the values can be passed in directly or derived from the commandContext() in the execute() function. For example:
{
    occupantId: “Jeremy”,
    roomFqn: “House1:LivingRoom”
}

Or more dynamically (note, the code below is just representative, the actual codes can be seen in the included script files):
{
    occupantId: commandContext().occupantWhoEntered,
    roomFqn: commandContext().camera.room
}</td><td></td></tr>
</table>

Operations		
Operation	**Description**	**Throws**
public **execute**() : void	This will evaluate the passed in commandString and pass the results to “moveOccupant(token, occupantFqn, roomFqn)”	ItemNotFoundException

Class::SetOccupantActivityCommand

Implements Interface::Command

This class encapsulates the data needed to perform a setOccupantActivity() command in the HMMS.

Attributes		
Attribute	**Description**	**Throws**

- commandString : String	A javascript snippet that returns an object with of the form:
	{
	occupantId: “some_occupant_id”,
	activityState: “true I false”
	}
	
	Like the MoveUpdateCommand, the values can be passed in directly or derived from the commandContext() in the execute() function. For example:
	{
	occupantId: “Jeremy”,
	activityState: true
	}
	
	Or more dynamically (note, the code below is just representative, the actual codes can be seen in the included script files):
	{
	occupantId: commandContext().occupantWhoIsOnCouch,
	activityState: false
	}	

Operations		
Operation	**Description**	**Throws**
public **execute**() : void	This will evaluate the passed in commandString and pass the results to “setOccupantActivity(token, occupantFqn, activityState)” in the HMMS	ItemNotFoundException

Interface::Context

Interface that provides methods for accessing data 'Contexts' that can be used with Predicate objects. Has a generic type parameter that will be provided by implementors that determines what kind of data will be returned from "getContext()"

Operations		
Operation	**Description**	**Throws**
public **populate**() : void	Will populate the context object with data based on its configuration.	
public **serialize**() : Object	Returns the populated context data. The Object return types will be made concrete by the subclasses.	

Interface::ConfigItemContextComponent

Extends: Context

Abstract interface type that is used as the component class for a composite structure of ConfigItemContexts. Implemented by ConfigItemContext and ConfigItemContextCollection.

ConfigItemContext

Implements Interface::ConfigItemContextComponent

Provides context fetched from the HouseMateModel, by being configured with a ConfigItem concrete type and an FQN. These context objects will be associated with rules, populated and passed to predicates during the rule's match() operation.

Attributes		
Attribute	**Description**	**Throws**
- configItemType : String	The concrete type of ConfigItem from the House Mate Model.	
- fqn : String	The FQN of the item for which to fetch context.	

Operations		
Operation	**Description**	**Throws**
public **populate**() : void	Based on the configItemType will call the appropriate "show" method in the HouseMateModelService	ItemNotFoundException
public **serialize**() : <Map<String,Map<String,String>>>	Will return all Triples fetched from the HouseMateModelSerivce as a 2-D map, where the top level keys are all subjects in the context and the values are a list of predicate/object pairs for that subject. For example: device1:Temperature is_measuring 75 device1:Setting1 is_set_to something, would be: `{'device1:Temperature': {'is_measuring':75}, device1:Setting1': {'is_set_to':something}},`	

ConfigItemContextCollection

Implements Interface::ConfigItemContextComponent

Basically a collection of ConfigItemContex objects. But it implements the Context interface so that the “Serialize” method will return serialized data for every associated ConfigItemContext obejct. Creating a composite class like this may be overkill for the basic implementation because we might as well always use the entire HMMS context for each rule. However, if the HMMS context grew exceedingly larger, or if another subclass fetched its data from a remote service, we may not want to use the entire state as context since most of it wouldn’t be useful to a Rules’ Predicates or Commands.

Attributes		
Attribute	**Description**	**Throws**
- contexts : List<ConfigItemContextCompone nt>	A list of ConfigItemContextComponent objects. This is a composite, that allows for collections to be added to other collections since a ConfigItemContextCollection is a ConfigItemContextComponent	

Operations		
Operation	**Description**	**Throws**
public **serialize**() : <Map<String,Map<String,String>>>	Will call serialize() on all of items in ‘contexts’ and merge them together into a <Map<String,Map<String,String>>>	

Exception Handling

In addition to ImportException and QueryEngineException from KnoweldgeGraph, the following additional exception classes are available. See class dictionary for what methods throw errors.

UnauthorizedException

Thrown when passing an invalid auth token to an API call in HouseMateControllerService.

ControllerNamedItemExistsException

Thrown when trying to add an named controller item that already exists.

Attributes	
Attribute	**Description**
private **name :** String	The name of the item that already exists.

ItemNotFoundException

Thrown when operation depends on an item that doesn't exists in the configuration.

Attributes	
Attribute	**Description**
private **fqn** : String	The fully qualified name that was requested or depended on, but not found. For example, will be thrown when adding a room to a house that doesn't exist.

CommandExecutionException

Thrown when trying to execute a command that fails. Since commands have dependencies on the HMMS, this will wrap exceptions coming from that service into a CommandExecutionException and display the commandId of the failing command.

Attributes	
Attribute	**Description**
private **e** : Exception	The exception that caused this exception to be thrown.
private **c** : Command	The command that threw the Exception

InvalidPredicateString

Thrown when trying to create a predicate with an invalid predicate string.

Attributes	
Attribute	**Description**
private **predicateString** : String	The passed in predicate string

InvalidContextString

Thrown when trying to create a Context with an invalid context string.

Attributes	
Attribute	**Description**
private **contextString** : String	The passed in context string

Implementation Details

The implementation will support a dynamically configurable controller system. For the puposes of this phase the controller configuration will only be stored in memory and not persisted to disk. The configurations will not be stored to the knowledge base.

There is a heavy reliance on passing in script ‘snippets’ to configure commands and predicates. I went with this approach to achieve flexibility, at the cost of possible complexity, abstraction and ‘inner-platform’ risk. Ultimately, the script ‘snippets’ could be hardened and packaged to reduce the need for clients/users to bootstrap so much of the system using configuration scripts.

Modifications to the HouseMateModelService

Added new public API call:

```
+ List<String> getFeature(String authToken, String featureFqn).
```

This behaves just like the getFeature(String authToken, String deviceFqn, String deviceStateFqn); except it takes a fully qualified Feature FQN as a single argument.

A note on Predicates

One key piece of the implementation for this design is how the Predicates will be created. For now, they will be created by a Predicate creator that will return Java platform Predicates of type Predicate<Map<String, Map<String,String>>>.The predicate creator will take the JavaScript passed in the Controller Service ‘createPredicate()’ execute that JavaScript in the JavaScript ScriptEngine. The engine will be passed the Predicate test parameter (the Map<String, Map<String, String>>) object and use standard javascript style . notation to read and test the context data.

A rule will take any Predicate type, as there is a clear case to create different types of predicates that use native Java code. For example, the system could be enhanced to read in plug-in jar files that contain native java predicates and use those instead of or in addition to JavaScript predicates. I’m going with the JavaScript style for now in order to make the system flexible and configurable.

A note on Logging

All key events will be logged for auditing and replay/undo possibilities. This includes:

- Feature Updates
- Observer Updates
- Rule match() executions
- Predicate tests (with context information)
- Command executions

This implementation will simply use System.out to perform console logging.

Testing

Unit Testing

Use JUnit test classes for each concrete class. Unit tests will be executed @ build time. This is made pretty easy by using IntelliJ.

Command/Integration Testing

Implement a test driver class called ControllerTestDriver that implements a static main() method. The main() method accepts a script file that has command lines that include commands to bootstrap the Model with houses/rooms/devices/features.

The command for the controller will be added to the CommandInterface class from Asn2. They are:

```
create rule {rulename}

create feature_update_command name {commandname} instructions
{jsString}

create move_occupant_command name {commandname} instructions
{jsString}

create set_occupant_activity_command name {commandname}
instructions {jsString}

create rule_predicate name {predicatename} test {jsString}

create context name {contextname} type {room|house|device|
feature|all} fqn {itemFqn}

show rules

show predicates

show contexts

add command {commandname} rule {rulename}

add predicate {predicatename} rule {rulename}

add context {contextname} rule {rulename}

remove command {commandname} rule {rulename}

remove predicate {predicatename} rule {rulename}

remove context {contextname} rule {rulename}

subscribe feature {featureFqn} rule {rulename}

unsubscribe feature (.*) rule (.*)
```

Subsequent to the setup, commands mimicking the updating of sensor and setting data will tigger rules to be executed and commands invoked.

To test the system, the script will:
Create rules for each requirement in the requirements document, which consists of:

- Creating Commands

- Creating Predicates
- Creating Contexts
- And then attaching them all to a rule
- The rule will then be attached to a Feature as an observer of that features state changes

I will then update the feature state to trigger the rule.

All results will be logged and commented in an output file.

A script file will be create to illustrate meeting all of the ‘Rules’ in the requirements doc.

Additionally, scripts files will be created to demonstrate:

- Rule reuse
- New Custom devices that are interesting extensions of the system
- Commands that can be issued to multiple types of devices at once
- Failing Predicates will prevent rule from executing commands

Risks

- The major dependency on JavaScript snippets using serialized “Context” objects favors configurability and post-compile flexibility over statically defined device types and structure. As such, a ‘mini-language/platform’ emerges which might be hard to debug, etc. See https://en.wikipedia.org/wiki/Inner-platform_effect. Ultimately this could be mitigated by extending the JS platform to be a formally defined scripting language, which was I didn’t take on as part of this scope. An alternative is to extend to a plugin architecture, where Predicate and Command objects can be defined in JAR files or provided as CORBA objects from a service; Then when composing rules using the command interface, the script will refer to the named Predicates and Command objects already loaded into the system.

- Accepting raw (JS) code as the predicate code makes the system subject to injection attacks.
- Rules could trigger an infinite loop of observe -> match -> update cycles if not careful.
- Referring to controller configuration objects by “Name” is not the most referentially sound method.