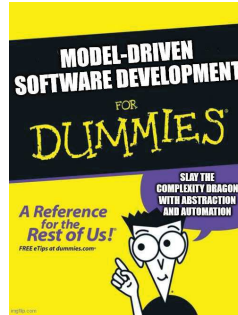


CISC836: Models in Software Development: Methods, Techniques and Tools



UML-RT and RSARTE Part VI: Integrating Models

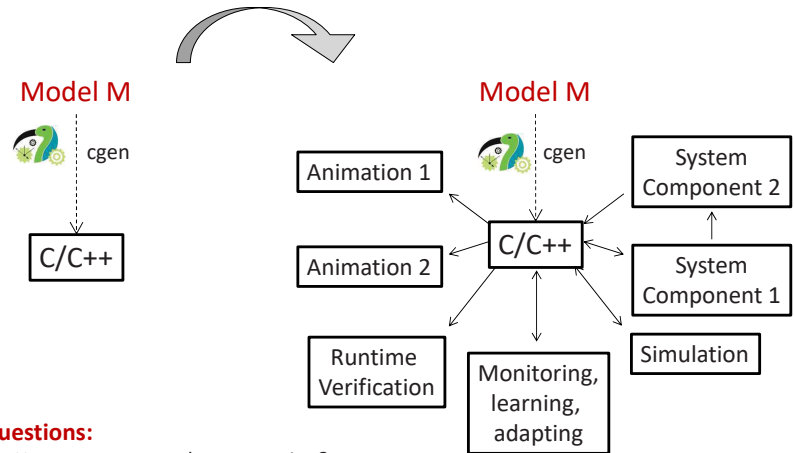
Juergen Dingel
Oct 2021

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From Isolated to Connected



Questions:

1. How to represent the connection?
2. Which communication mechanisms to support?

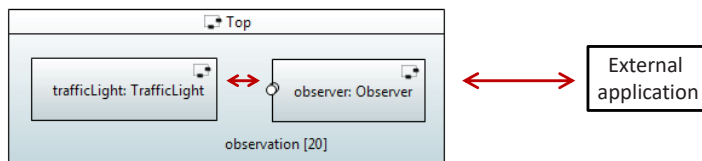
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Representing Connections: Option 1 Observer Capsule

- **Dedicated, yet general capsule**
 - Serving as generic 'gateway'
- **Connector**
 - Dynamic, automatic, name-based registration (SAP/SPP)
- **Messages**
 - Single outgoing message 'event(data)' with general data format
 - Incoming messages can be added



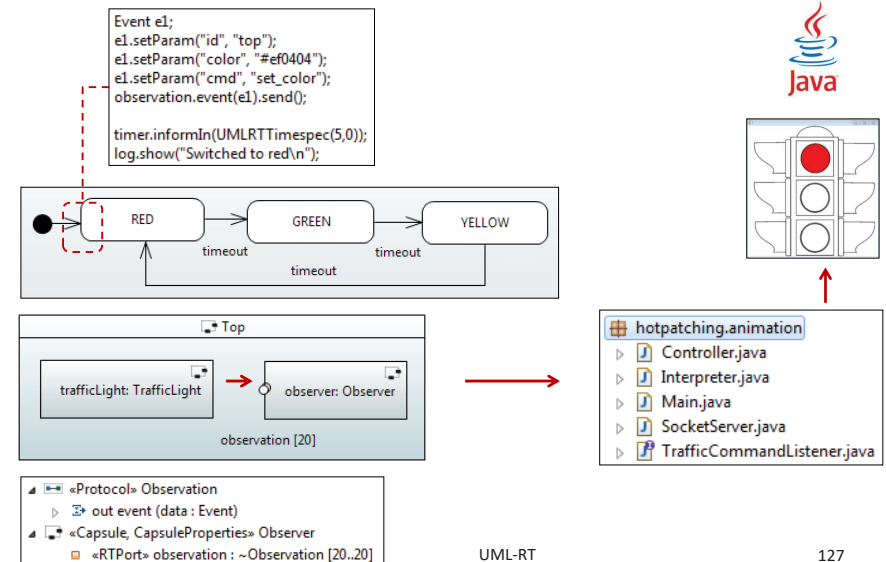
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Observer Capsule: Examples

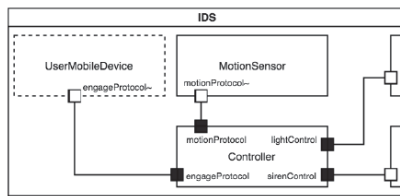
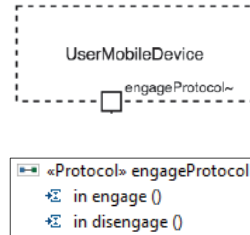


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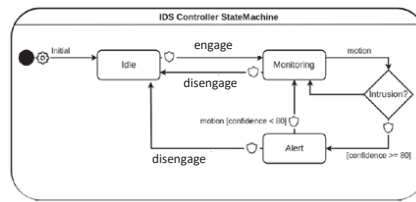
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Representing Connections: Option 2 Proxy Capsule

- **Dedicated, application-specific capsule**
 - Representing specific, application-relevant, external component
- **Messages**
 - Component-specific protocol



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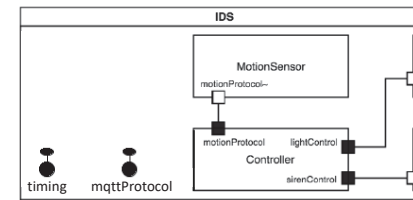


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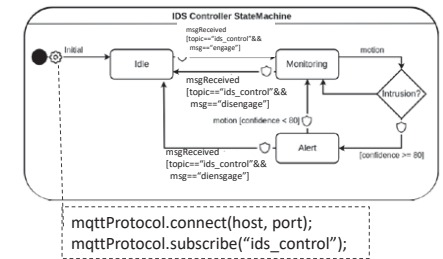
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Representing Connections: Option 3 System Ports

- **Protocol-specific extension to RTS**
 - Similar to, e.g., timing services
- **Messages**
 - RTS developer defined



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Representing Connections: Summary

	Shown in capsule diagram?	Messages	Suitability
Observer capsule	Yes	Single, pre-defined out message	Animation, RT monitoring, (steering)
Proxy capsule	Yes	Capsule-specific, defined by user	Integration
System port	No	Protocol-specific, defined by RTS developer	Integration

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Connecting: Communication Mechanisms

- **Shared memory**
- **Communication protocols**
 - TCP/IP
 - Publish/subscribe
 - MQTT
 - DDS
 - Request/response
 - CoAP
- **Serialization**
 - JSON
 - Widely used, ASCII representation
 - Flatbuffers (Google)
 - Interface Definition Language, binary encoding

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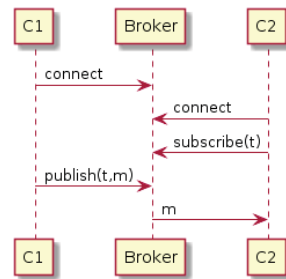
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Communication Protocols: MQTT

Message Queue Telemetry Transport (MQTT)

- Publish/subscribe protocol
- Light-weight, low resource requirements
- Easy to use:
 - connect(brokerAddr, brokerPort), disconnect(),
 - subscribe(topic), unsubscribe(),
 - publish(topic, message)
- Standardized (ISO)



Broker

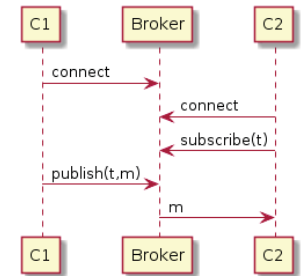
Ensures that all subscribers to a specific topic receive every message published to that topic

Topic	Subscribers
"Temperature/bedroom"	Component 2
...	...

Communication Protocols: MQTT (Cont'd)

Topics as filters

- Can be **hierarchical**, e.g.,
`office/floor1/room1/temperature/`
 will match
`office/floor1`
- Can contain **wildcards**, e.g.,
 single level: `office/floor1/+temperature`
 multi level: `office/*/temperature`



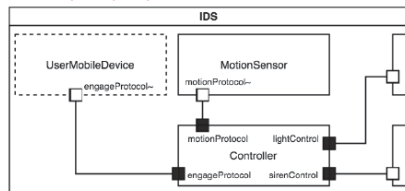
Implementations

- E.g.,
 - Eclipse Paho: MQTT clients for 10 different languages
 - Eclipse Mosquitto: MQTT broker

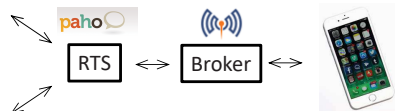
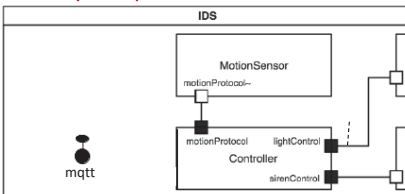


TCP/IP and MQTT in Papyrus-RT

MQTT proxy capsule w/ JSON



MQTT system ports



RTS Library Extension: MQTTProxyCapsule

MQTTProxyCapsule (in mqttproxycapsule.hh)

Properties

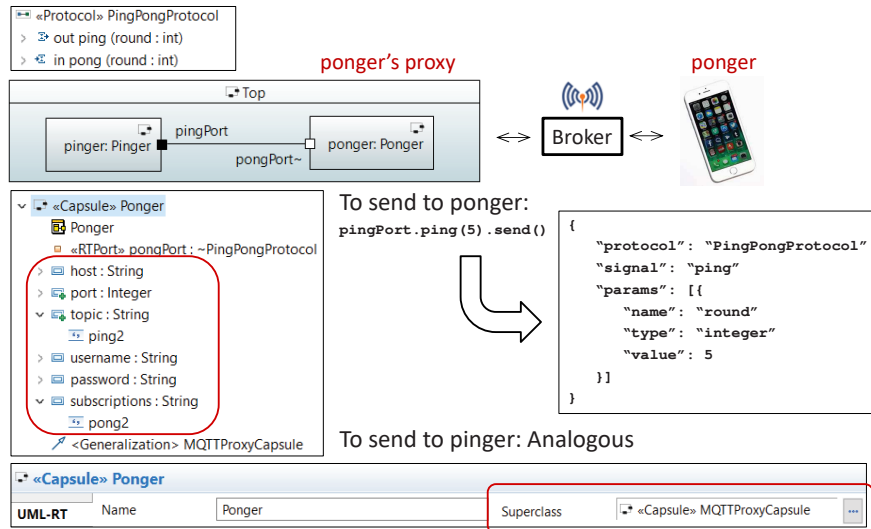
- `host: String, port: Integer` // to connect to broker
- `topic: String` // topic of the messages sent
- `subscriptions: String` // topics subscribed to
- `username, password: String`

Assumptions

- Proxy capsule
 - extends `MQTTProxyCapsule`
 - must have exactly one port (conjugate)
- Implementing external component
 - subscribed to topics listed in 'subscriptions'
 - publishes input messages listed in port's protocol to topic 'topic'
- 'subscriptions' has format "topic1; topic2; ...; topicn"



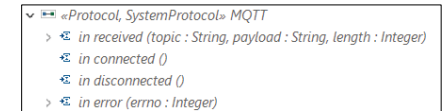
RTS Library Extension: MQTTProxyCapsule (Cont'd)



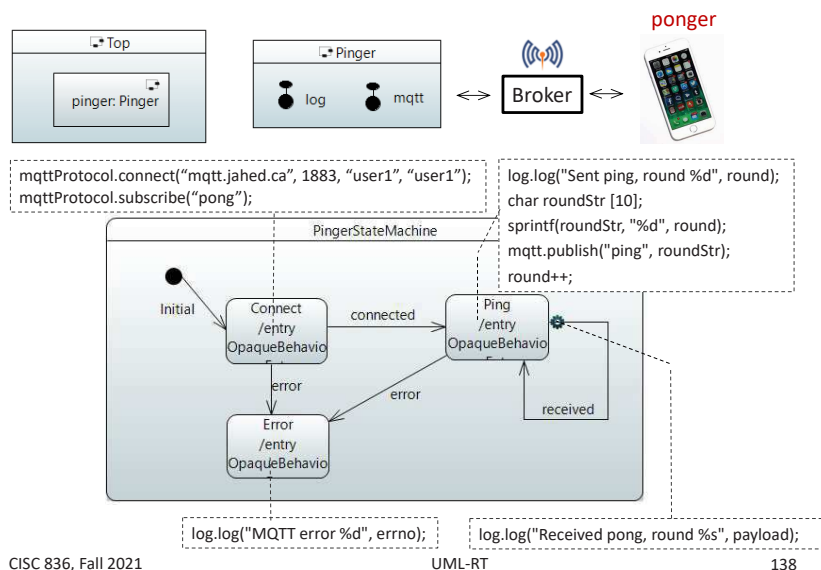
RTS Library Extension: MQTT System Port

UMLRTMQTTProtocol (in umlrtmqttprotocol.hh)

- Type of MQTT system port
- Methods implemented
 - `connect(host:String, port:Integer, uname:String, pwd:String)`
E.g.: `mqtt.connect("mqtt.jahed.ca", 1883, "user1", "user1");`
 - `disconnect()`
 - `subscribe(topic: String)`
E.g.: `mqtt.subscribe("pong");`
 - `publish(topic:string, msg:String)`
E.g.: `mqtt.publish("ping", roundStr);`
- Messages generated
 - `connected()`
 - `disconnected()`
 - `error(errno: Integer)`
 - `received(topic:String, payload:String, length:Integer)`



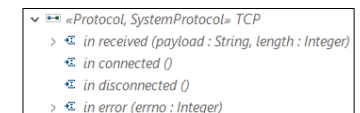
MQTT System Port: Example

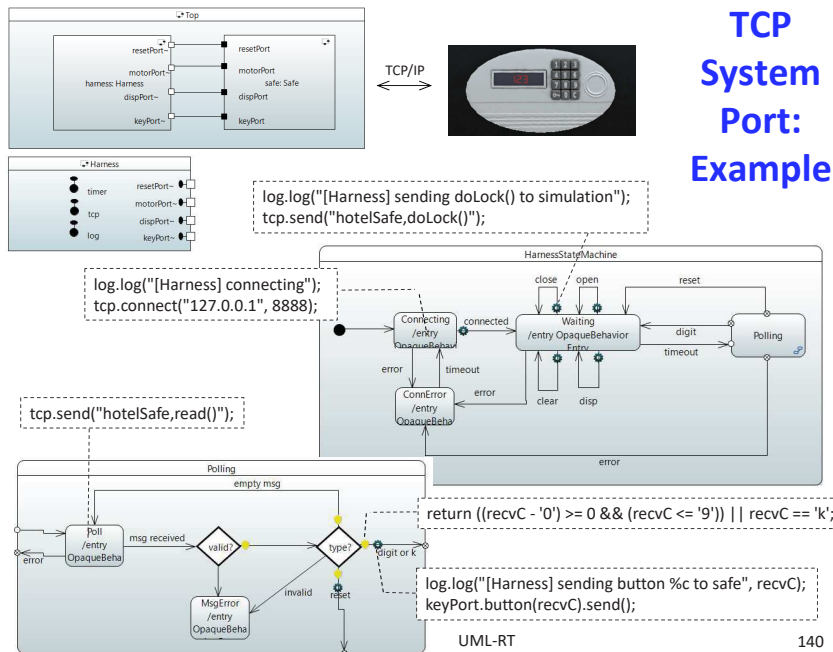


RTS Library Extension: TCP System Port

UMLRTTCPProtocol (in umlrttcpprotocol.hh)

- Type of TCP system port
- Methods implemented
 - `connect(host:String, port:Integer)`
E.g.: `tcp.connect("127.0.0.1", 8888);`
 - `disconnect()`
 - `send(msg:String)`
E.g.: `tcp.send("hotelSafe, doLock()");`
- Messages generated
 - `connected()`
 - `disconnected()`
 - `error(errno: Integer)`
 - `received(topic:String, payload:String)`





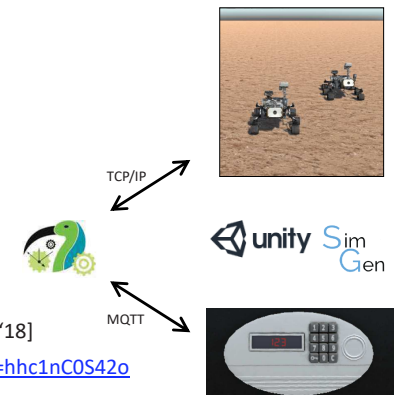
TCP/IP and MQTT in Papyrus-RT: Examples

System ports

- TCP/IP
- Rover challenge problem
[MDETools'18], [Pasternak et al '18]

Proxy capsules & system ports

- Hotel safe simulation [Dingel et al '18]
- <https://www.youtube.com/watch?v=hhc1nC0S42o>



[MDETools'18] Bagherzadeh, Bordeleau, Dingel, Famelis, Garcia-Dominguez, Oliveira, Posse, Seidewitz, Selic. 2nd Workshop on MDE Tools. MODELS'18. 2018

[Pasternak et al '18] Pasternak, Kahani, Bagherzadeh, Dingel, Cody. "SimGen: A tool for generating simulations and visualizations of embedded systems on the Unity Game Engine". MODELS'18 Demo Track. 2018

[Dingel et al '18] Dingel, Jahed, Posse. "Making modeling cool again". Tutorial at MODELS'18. Materials available at <https://github.com/kjahed/Models18-MMCA>

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Other Communication Protocols

Data Distribution Service (DDS)

- Also pub/sub
- Compared to MQTT
 - Decentralized
 - For message-intensive M2M communication
 - Focus on high performance

Constrained Application Protocol (CoAP)

- Request/reply ala HTTP
- For resource-constrained environments

Communication Mechanisms: Summary

	Shared Memory	TCP/IP	MQTT	DDS	CoAP	Serialization	
						JSON	FlatBuffers
Observer Capsule	✓	✓					
Proxy Capsule			✓	✓	✓	✓	✓
System Ports		✓	✓				

✓ Available at <https://github.com/kjahed/>

✓ Experimental prototype. Please contact us