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A demonstration of autonomous RFID and telemetric sensor networks in logistics

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Collaborative Research Centre 637
University of Bremen

Agenda

- Telemetric Sensors
- Description of CRC Project
- Demonstration

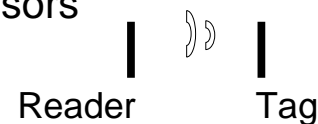
Telemetric Sensors

- Wireless Sensors based on:
 - Zigbee, Bluetooth, 802.11
 - Battery powered
 - Expensive



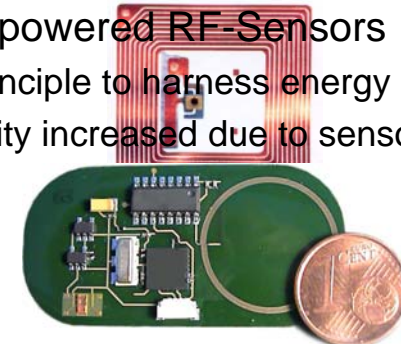
Picture sources: http://www.helioser.info/medialib_pic/small/2013.png
http://www.karputer.co.uk/images/product_image/thumb_086.gif
<http://www.wireless.co.uk/crc/2007/10/06-06-Bluetooth-Logo.jpg>

- Passively powered RF-Sensors
 - Passive tags require no batteries
 - Inexpensive and robust



RFIDs vs. RF-Sensors

- RFIDs
 - Passive tags harness electromagnetic energy
 - Data written to and read from static memory
- Passively powered RF-Sensors
 - Same principle to harness energy as RFIDs
 - Complexity increased due to sensor system



Example measurement problems

- MCB Projects
 - Monitoring contact pressure for medical compression stockings
 - Monitoring of automobile fluid levels
 - Anti-condensation system for automobiles



Source: <http://www.quickcaremedical.com/heart.gif>



Source: http://aimcast.org.uk/gallery/statamedia/200car_line1sm.jpg

Anti-Condensation System

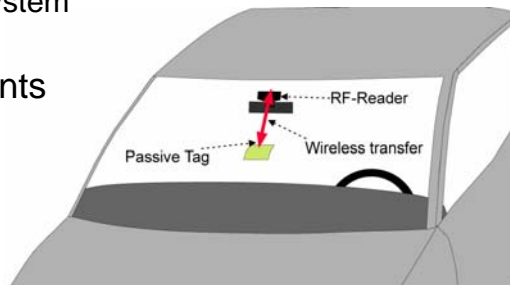
- Motivation
 - Detect condensation and automatically adjust defrost
 - Preventatively eliminate the formation of condensation
 - Increase safety and comfort for driver



Source: <http://eyemhphoto.com/670167-12.jpg>

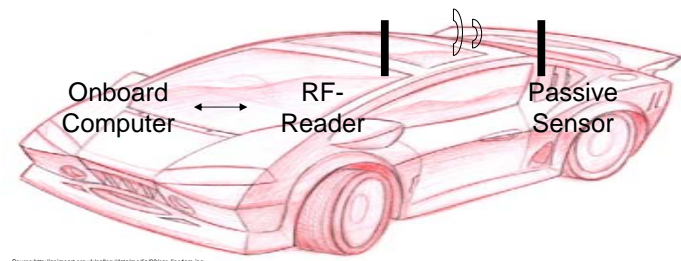
Anti-Condensation System

- System concept
 - Wirelessly measure temperature against the windshield
 - Calculate dew-point from temperature, humidity
 - Control heating system
- System requirements
 - Easy maintenance
 - Durable



Anti-Condensation System

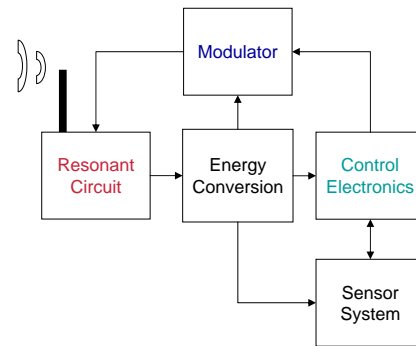
- System components and interaction
 - Onboard Computer request dewpoint information, control heating
 - RF-Reader query for temperature, calculate dewpoint
 - Passive sensor tag wirelessly measure temperature



Source: http://aimcast.org.uk/gallery/statamedia/200car_line1sm.jpg

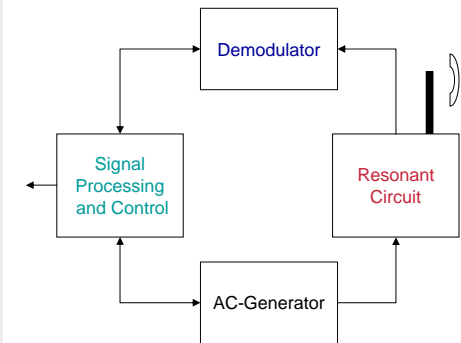
Anti-Condensation System

- Passive tag
 - Varying magnetic field induces EMF
 - Energy converted and regulated to DC
 - Measure temperature
 - Modulate temperature back to RFID-Reader via load modulation



Anti-Condensation System

- RF-Reader
 - Received data demodulated
 - Data is analyzed and processed
 - AC current generator creates time varying magnetic field



Passive RF-Sensor Challenges and Outlook

- Interdependency of subsystems
 - "If you optimize the components you will probably ruin the system's performance" - R. Hamming
- Expertise required from many areas
 - Electromagnetics, analog and mixed signal design, digital design, communications, software
- Increase operating distance, decrease cost
- Integrate RFIDs, passive RF-Sensors and other wireless systems

CRC 637 – Autonomous Logistic Processes

- Logistics demand for
 - increasing flexibility and robustness in supply chains
 - individually tailored logistic services
- Centralist manual process control will not be adequate anymore
- Need for intelligent local control strategies to meet the new requirements



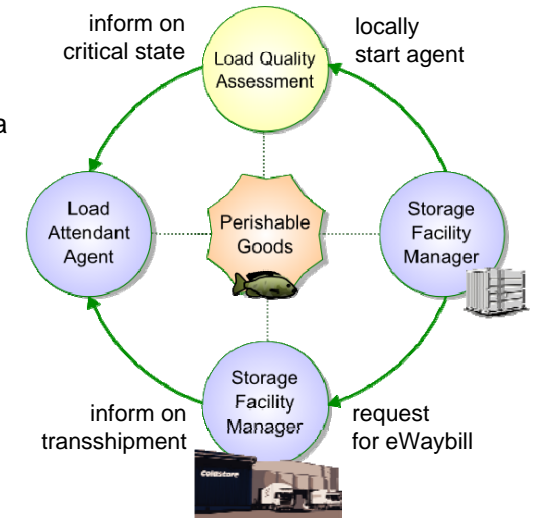
CRC 637 – Autonomous Logistic Processes

- CRC 637: long-term programme with about 40 researchers
- Development of new strategies and technologies for local autonomy in logistics
- Demonstration shows applications of
 - sensor networks
 - RFID
 - Multiagent Systems (MAS)

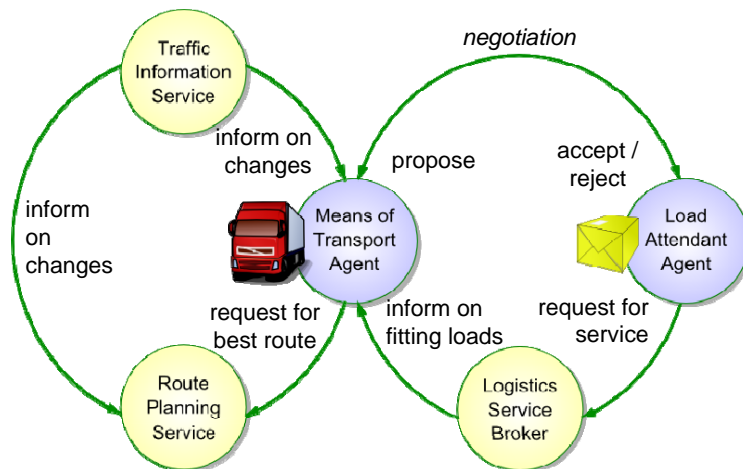


Agents and Agent Interactions (1)

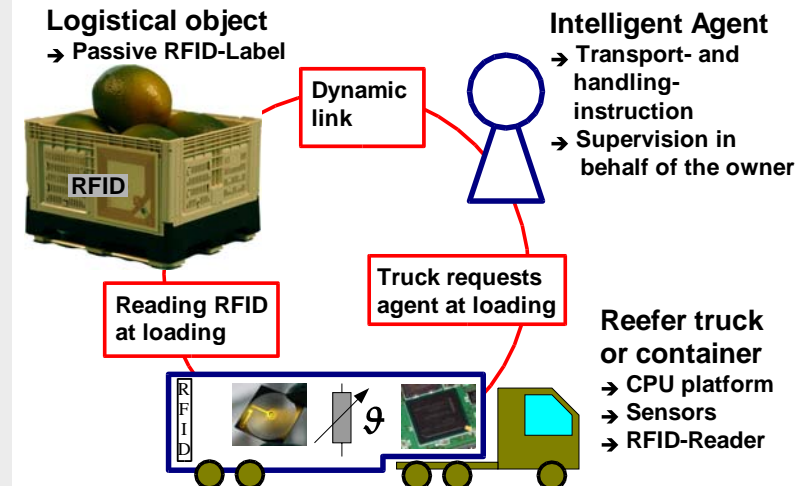
- Multiagent technology:
 - agents as software programmes
 - decide on behalf of a real-world entity
 - interact with other agents (FIPA)
- Logistic entities
 - represented as intelligent agents
 - autonomously coordinate and negotiate



Agents and Agent Interactions (2)



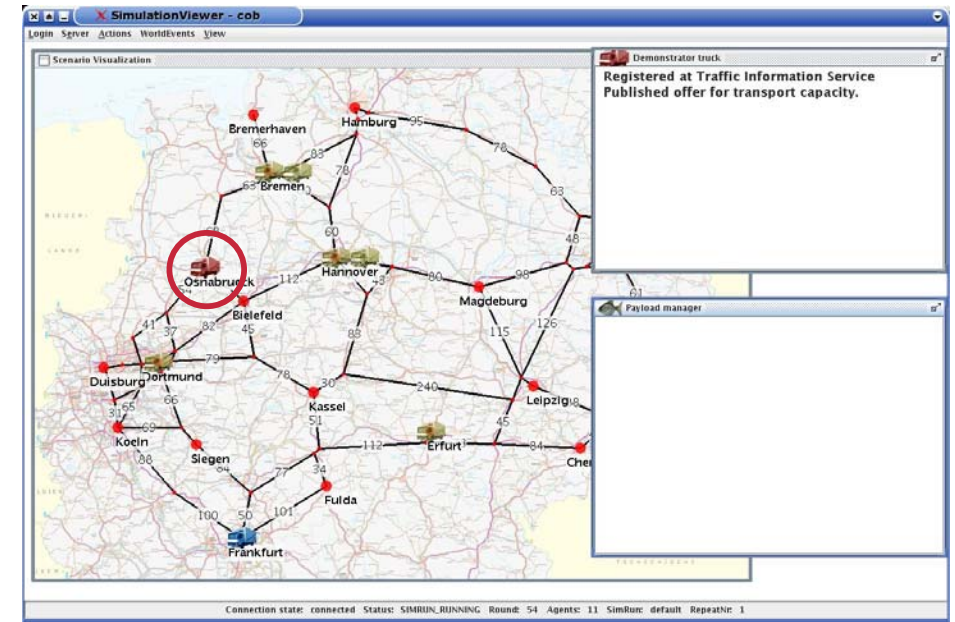
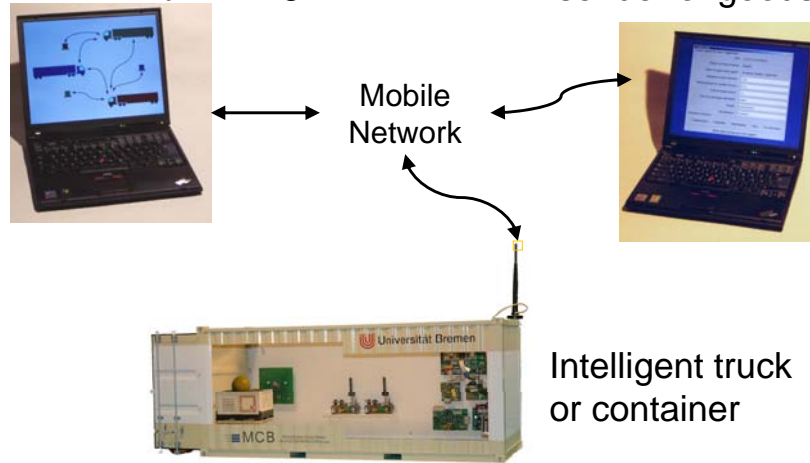
RFID Application in Logistics



Demonstrator Setting

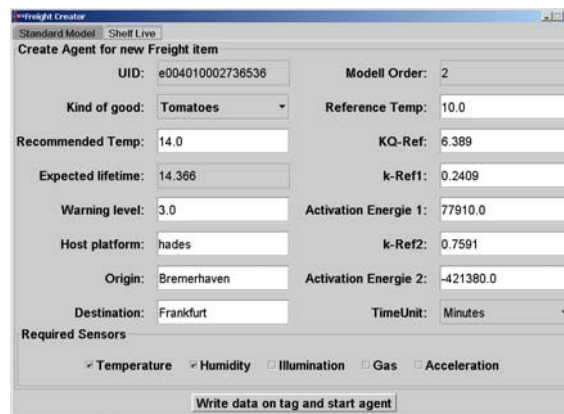
Transport coordination and route planning

Manufacturer or sender of goods

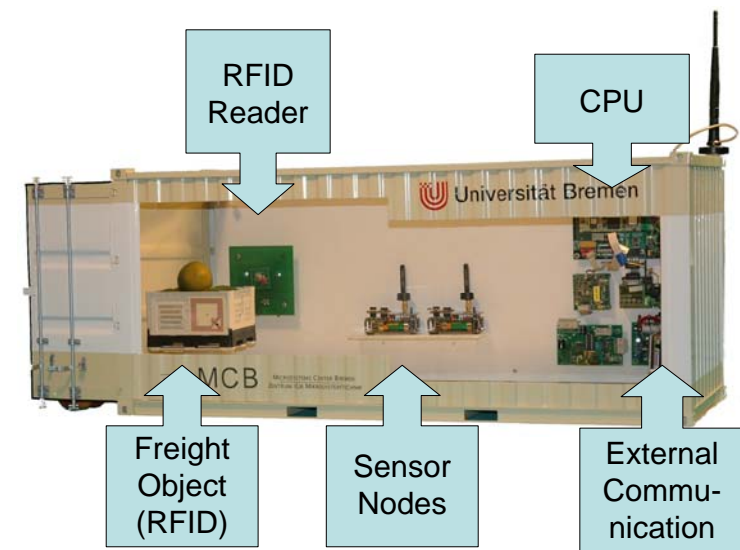


Configuration of the electronic consignment note

- The manufacturer or sender of goods defines the parameters (supported by a data base)



Hardware



Wireless Sensors

Multi point measurement inside the container

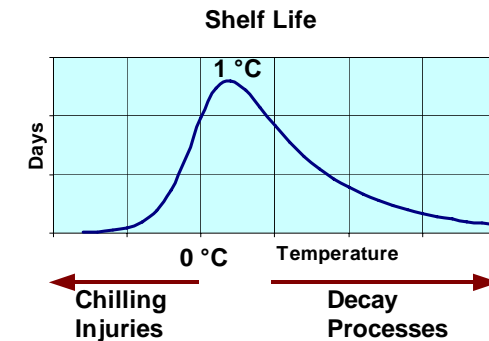
Ultra low power hardware design and protocols

Modules for temperature, humidity, light and shock / vibration



Dynamic Quality Models

- Prediction of quality changes caused by parameter deviations
- Shelf life model predicts remaining time before quality falls below acceptance limit
- Local processing to save communication costs



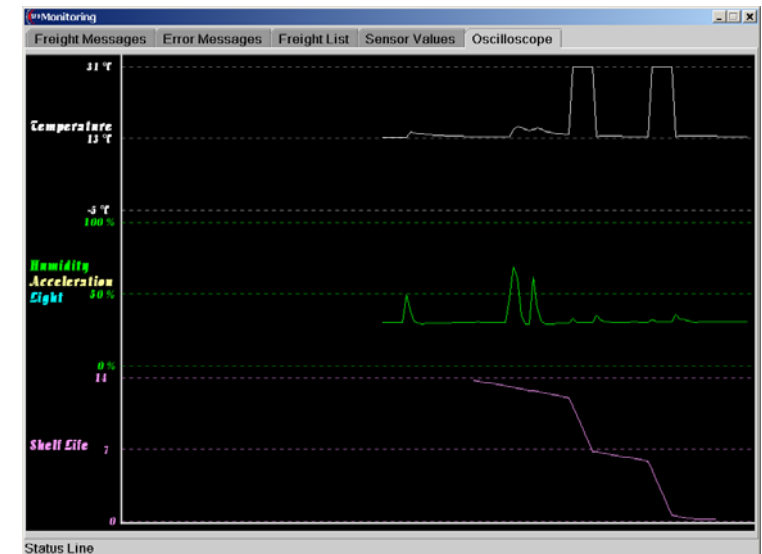
Online Monitoring

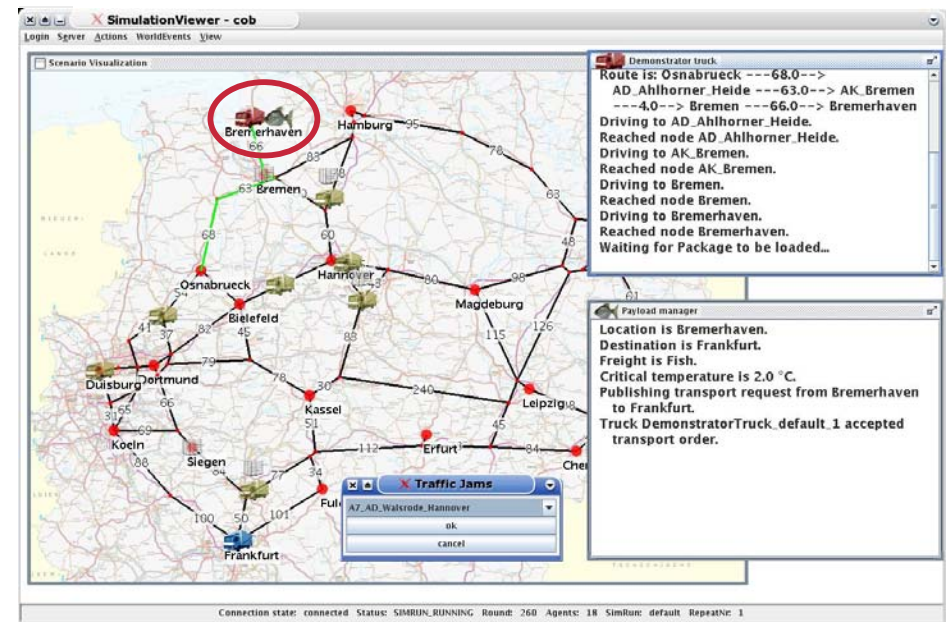
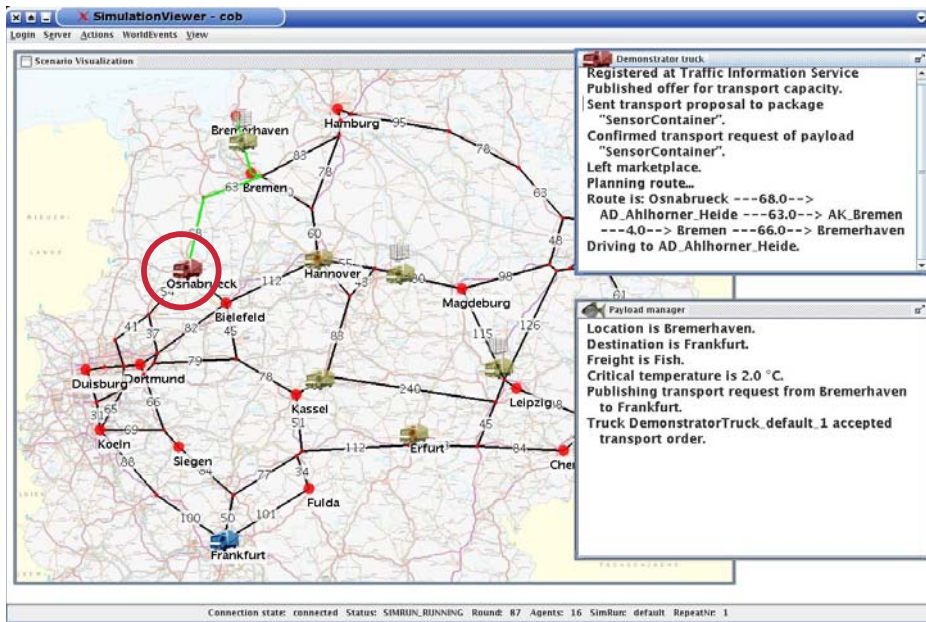
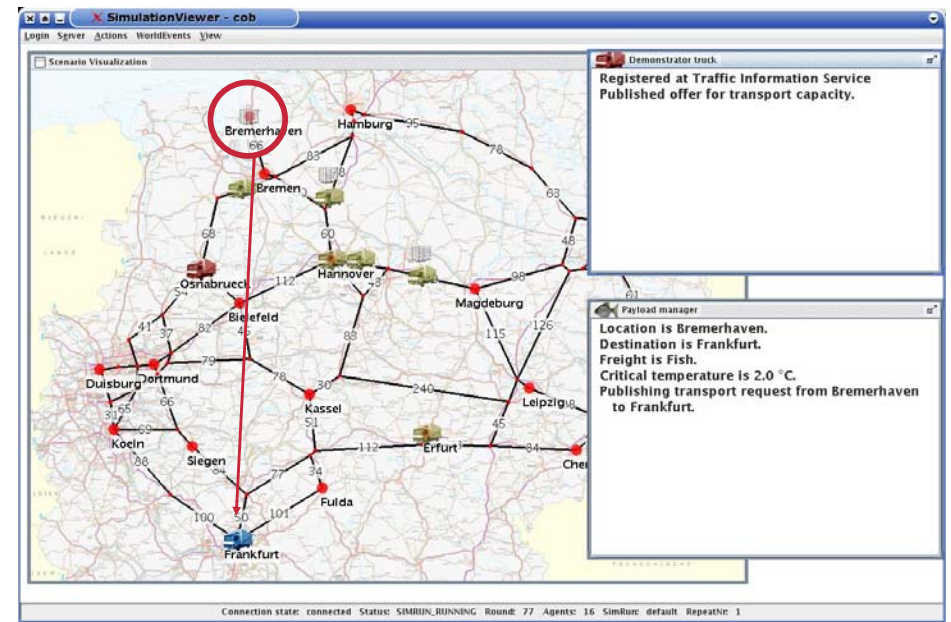
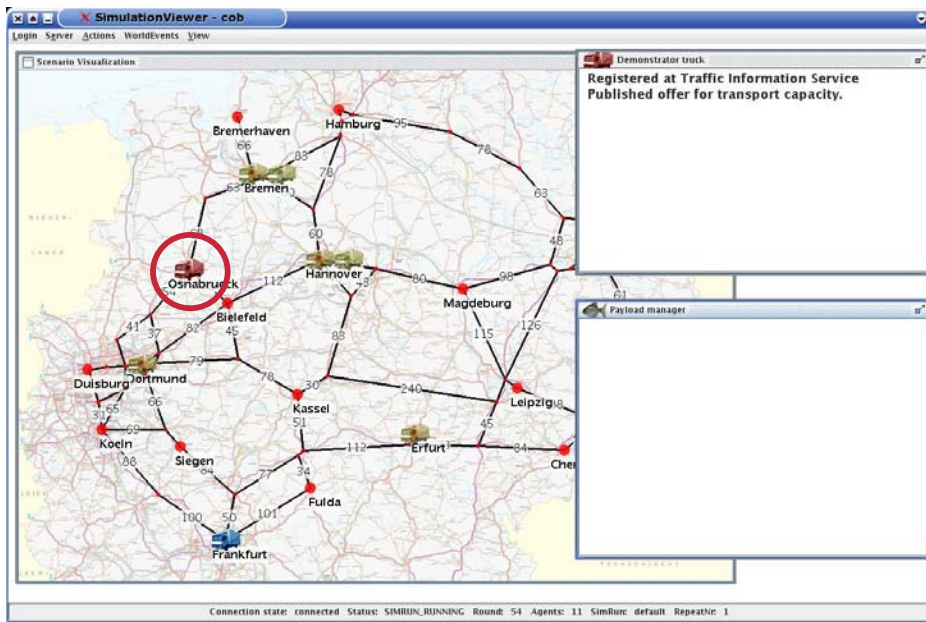
Time	Location	Error Messages	Freight List	Sensor Values	Oscilloscope	UID	Product	Priority	QIndex
15:58:49	Warehouse-97	Moved to new vehicle				e004010000588592	Fish	normal	38.3
15:55:23		Quality loss, take immediate action!				e004010000588592	Fish	yellow	74.01
15:54:59		Freight is losing quality				e004010000588592	Fish	normal	87.63
15:54:15		Critical Temperature overstepped				e004010000588592	Fish	yellow	97.46
15:54:11	Vehicle IP-82	OK - All Sensors available				e004010000588592	Fish	normal	98.13
15:53:57	Vehicle IP-82	Moved to new vehicle				e004010000588592	Fish	normal	98.13
15:53:53	Vehicle IP-82	Sensor missing: Humidity Temperature				e004010000588592	Fish	red	
15:51:36	Warehouse-97	Freight item waiting for transport				e004010000588592	Fish	normal	100

Time: 15:54:59
 Message: Freight is losing quality
 UID: e004010000588592
 Product: Fish
 Priority: normal
 QIndex: 87,63

e004010000588592: Moved to new vehicle

The look into the container





Scenario Visualization

Connection state: connected Status: SIMRUN_RUNNING Round: 267 Agents: 18 SimRun: default RepeatNr: 1

Demonstrator truck
 ---4.0--> Bremen ---66.0--> Bremerhaven
 Driving to AD_Ahlhorne_Heide.
 Reached node AD_Ahlhorne_Heide.
 Driving to AK_Bremen.
 Reached node Bremen.
 Driving to Bremerhaven.
 Reached node Bremerhaven.
 Waiting for Package to be loaded...
 Sensor missing: Humidity Temperature . Waiting for missing sensors to be loaded.

Payload manager
 Location is Bremerhaven.
 Destination is Frankfurt.
 Freight is Fish.
 Critical temperature is 2.0 °C.
 Publishing transport request from Bremerhaven to Frankfurt.
 Truck DemonstratorTruck.default_1 accepted transport order.
 Checking available sensors...
 Sensor status not okay - informing truck to add missing sensors.

Traffic Jams
 A7_AD_Walsrode_Hannover
 ok
 cancel

Scenario Visualization

Connection state: connected Status: SIMRUN_RUNNING Round: 307 Agents: 19 SimRun: default RepeatNr: 1

Demonstrator truck
 A7_AD_Walsrode_Hannover
 Traffic jam is on current route.
 Replanning route...
 New route is: Bremerhaven ---66.0--> Bremen
 ---4.0--> AK_Bremen ---63.0-->
 AD_Ahlhorne_Heide ---68.0--> Osnabrueck
 ---54.0--> AK_MuensterSued ---37.0-->
 AK_Kamen ---8.0--> AK_DortmundUnna
 ---15.0--> AK_Westhofen ---66.0-->
 AK_OlpeSued ---20.0--> Siegen ---84.0-->
 AK_Gambach ---50.0--> Frankfurt

Payload manager
 Destination is Frankfurt.
 Freight is Fish.
 Critical temperature is 2.0 °C.
 Publishing transport request from Bremerhaven to Frankfurt.
 Truck DemonstratorTruck.default_1 accepted transport order.
 Checking available sensors...
 Sensor status not okay - informing truck to add missing sensors.
 Checking available sensors...
 All necessary sensors available - informing truck permission to depart.

Scenario Visualization

Connection state: connected Status: SIMRUN_RUNNING Round: 287 Agents: 16 SimRun: default RepeatNr: 1

Demonstrator truck
 Reached node AK_Bremen.
 Driving to Bremen.
 Reached node Bremen.
 Driving to Bremerhaven.
 Reached node Bremerhaven.
 Waiting for Package to be loaded...
 Sensor missing: Humidity Temperature . Waiting for missing sensors to be loaded.
 All necessary sensors available. Package loading confirmed by ID reader.
 Driving to Bremen.

Payload manager
 Destination is Frankfurt.
 Freight is Fish.
 Critical temperature is 2.0 °C.
 Publishing transport request from Bremerhaven to Frankfurt.
 Truck DemonstratorTruck.default_1 accepted transport order.
 Checking available sensors...
 Sensor status not okay - informing truck to add missing sensors.
 Checking available sensors...
 All necessary sensors available - informing truck permission to depart.

Traffic Jams
 A7_AD_Walsrode_Hannover
 ok
 cancel

Scenario Visualization

Connection state: connected Status: SIMRUN_RUNNING Round: 381 Agents: 17 SimRun: default RepeatNr: 1

Demonstrator truck
 Payload requested new destination: Kassel
 Reason is too high temperature.
 Replanning route...
 New route is: Bremerhaven ---66.0--> Bremen
 ---4.0--> AK_Bremen ---63.0-->
 AD_Ahlhorne_Heide ---68.0--> Osnabrueck
 ---52.0--> Bielefeld ---45.0-->
 AK_Wuennenberg ---78.0--> Kassel
 Filling new goal: Cooling unit needs to be checked. Setting new status: Not free for new orders.

Payload manager
 permission to depart.
 Received sensor warning (rising temperature). Risk to high for original plan: (directly reaching Frankfurt).
 Searching alternatives.
 Searching for refrigerated warehouse for changing to another truck.
 Found Bremerhaven, Dortmund, Hamm, and Frankfurt.
 Selecting intermediate warehouse Kassel for exchange.
 Sent changed destination (Kassel) to truck.
 Requesting unload and intermediate storage.

