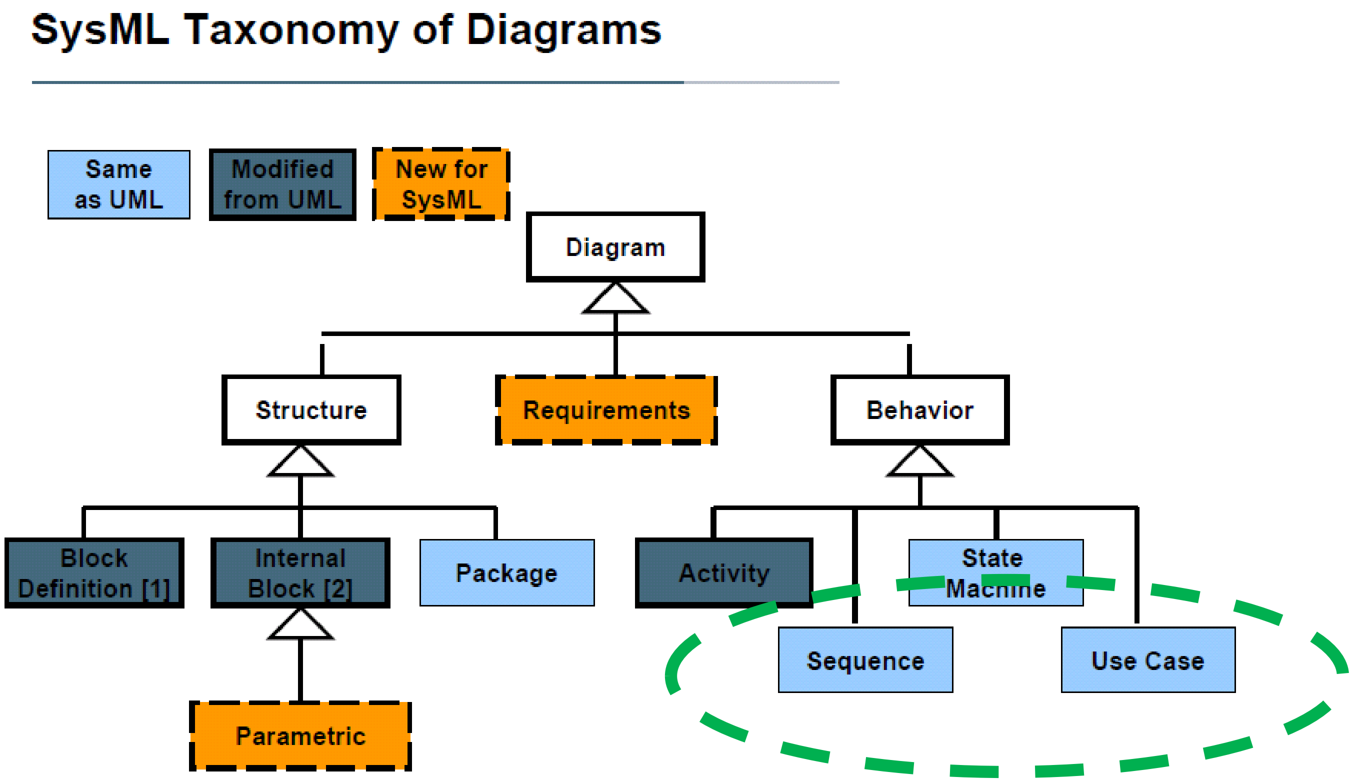
SysEng 6542
Model Based Systems Engineering

Modeling Behavior – Part 2

Dr Quoc Do

Scope


SysML Taxonomy of Diagrams
Same as UML
Modified from UML
New for SysML
Diagram
Structure
Requirements
Behavior
Block Definition [1]
Internal Block [2]
Package
Activity
State Machine
Sequence
Use Case
Parametric

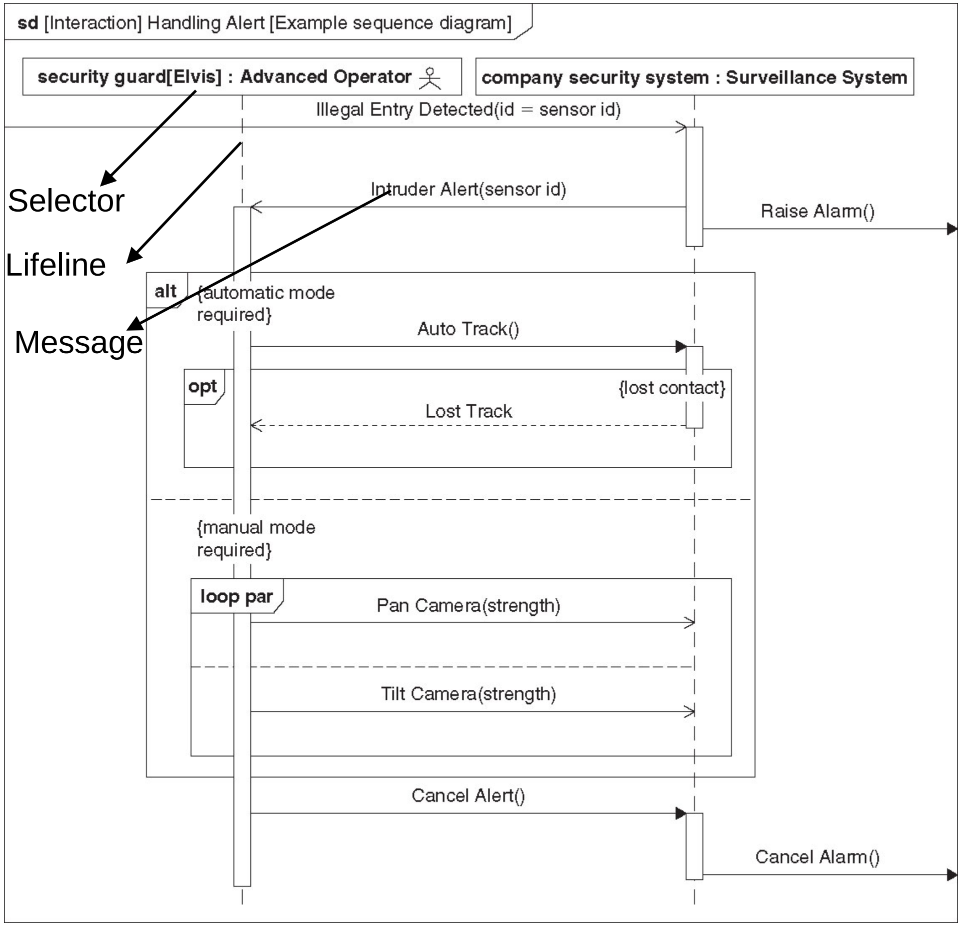
Sequence Diagram

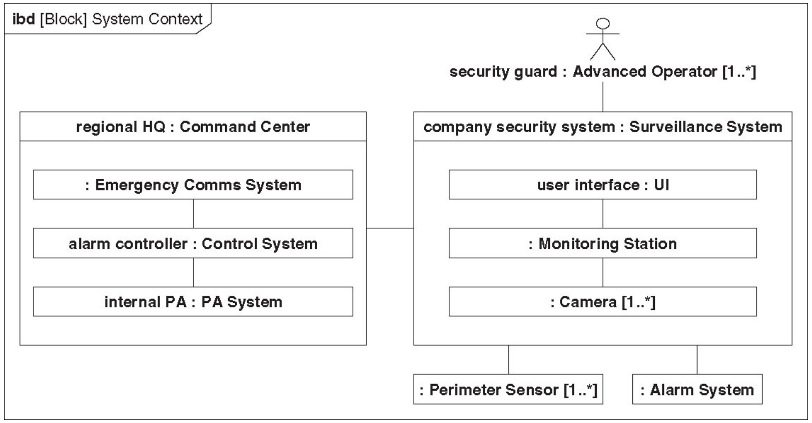
- UML Behavior Diagram
- Represents Message-based behavior and interaction between system components and any externals (actors, environment, etc.)
- Only represent interactions, so no model element type necessary

Sequence Diagram

An example

- Interactions take place in the context of a block. The example show interaction within a *System Context* block.


sd [Interaction] Handling Alert [Example sequence diagram]
security guard[Elvis] : Advanced Operator
company security system : Surveillance System
Illegal Entry Detected(id = sensor id)
Selector
Lifeline
Message
Intruder Alert(sensor id)
Raise Alarm()
alt
{automatic mode required}
Auto Track()
opt
{lost contact}
Lost Track
{manual mode required}
loop par
Pan Camera(strength)
Tilt Camera(strength)
Cancel Alert()
Cancel Alarm()

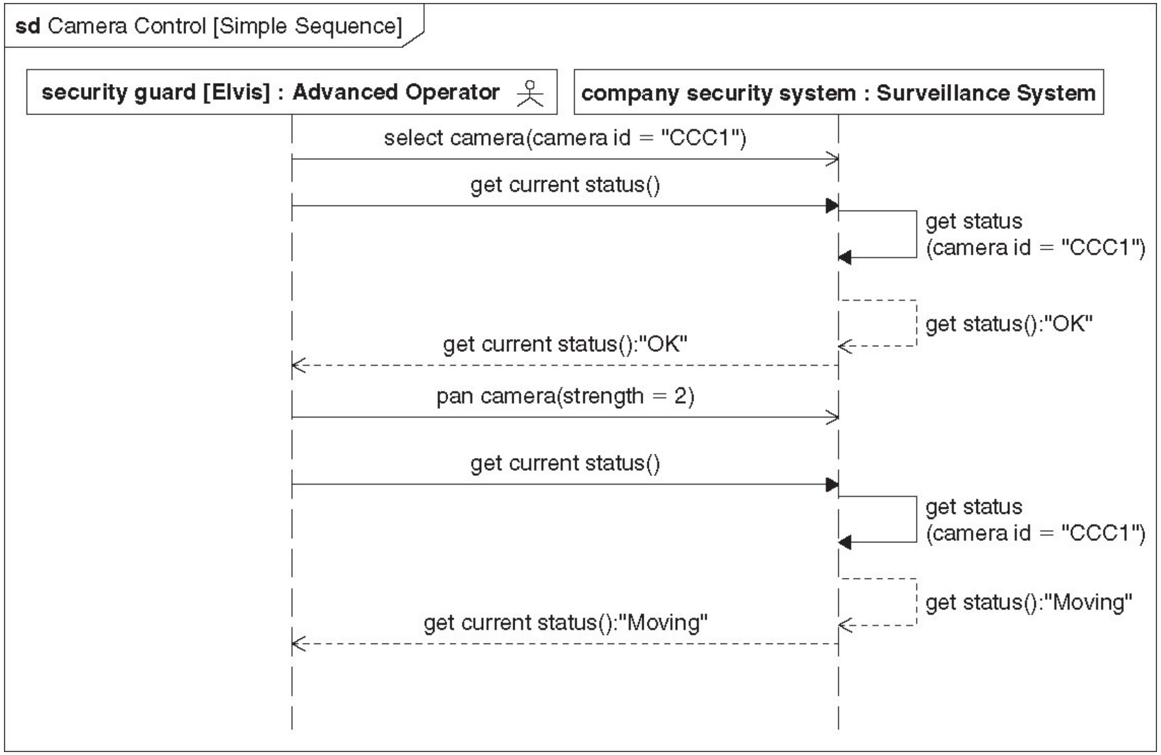

ibd [Block] System Context
security guard : Advanced Operator [1..*]
regional HQ : Command Center
: Emergency Comms System
alarm controller : Control System
internal PA : PA System
company security system : Surveillance System
user interface : UI
: Monitoring Station
: Camera [1..*]
: Perimeter Sensor [1..*]
: Alarm System

Events and Occurrences

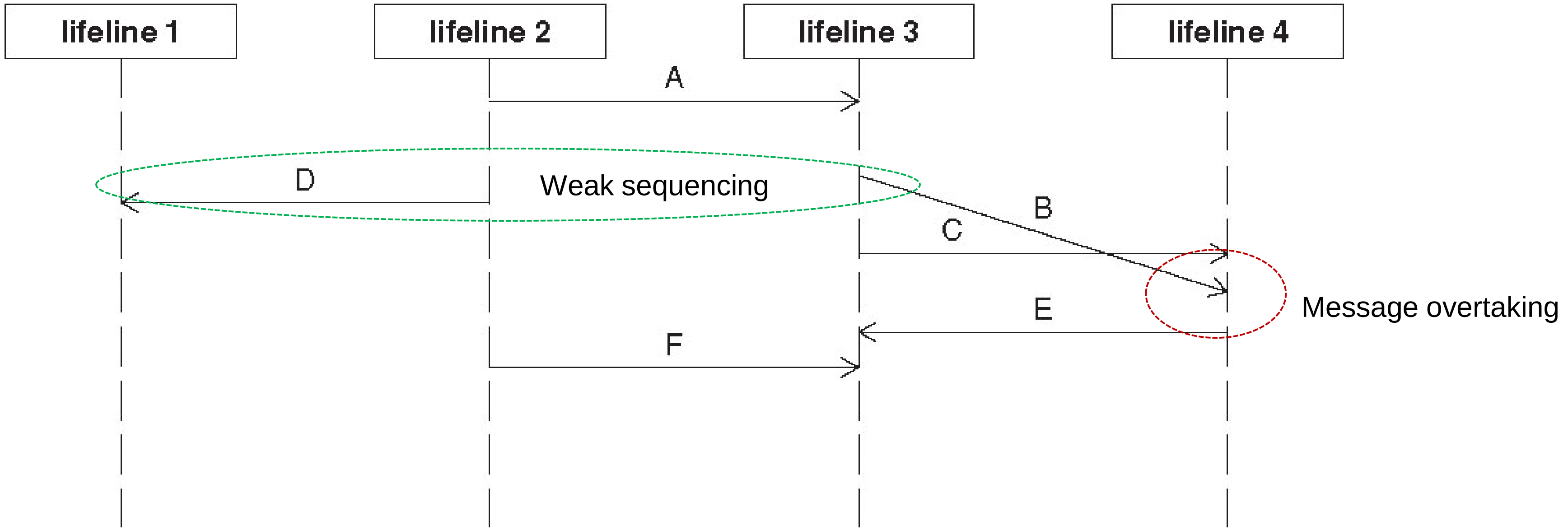
- Events – an ordered list of things that happen along a lifeline
- Occurrences – instances of events during interaction
- Trace – an interaction to validate an ordered set of occurrences in time
- There are three categories of events:
  - The sending and receiving of messages;
  - The start and completion of execution of actions and behavior; and
  - Creation and destruction of instances

Synchronous/Asynchronous

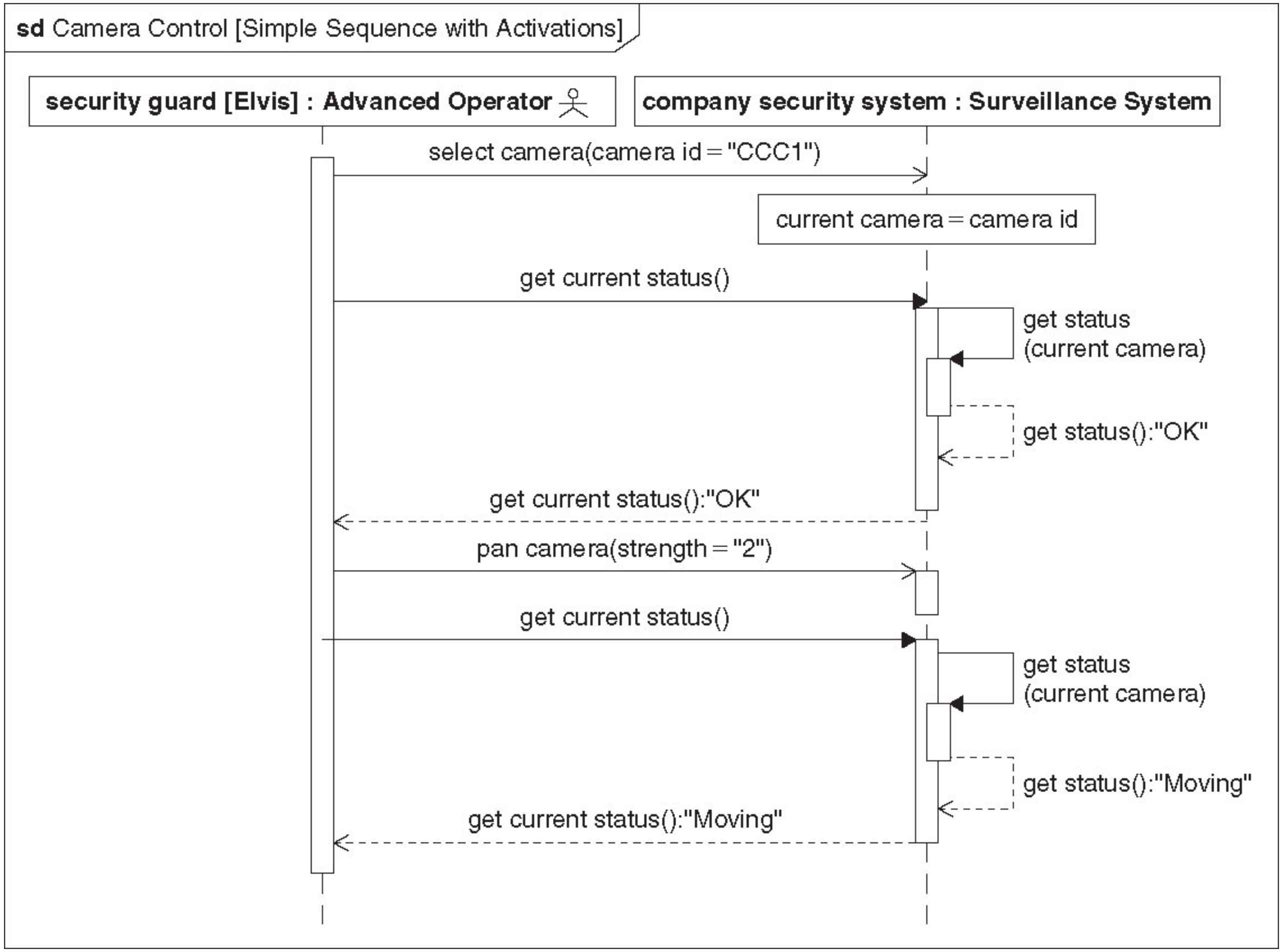
- Synchronous – wait for a response (closed arrowhead)
- Asynchronous – send message and continue (open arrowhead)
- Reply – dashed line & open arrowhead


sd Camera Control [Simple Sequence]
security guard [Elvis] : Advanced Operator
company security system : Surveillance System
select camera(camera id = "CCC1")
get current status()
get status
(camera id = "CCC1")
get status():"OK"
get current status():"OK"
pan camera(strength = 2)
get current status()
get status
(camera id = "CCC1")
get status():"Moving"
get current status():"Moving"

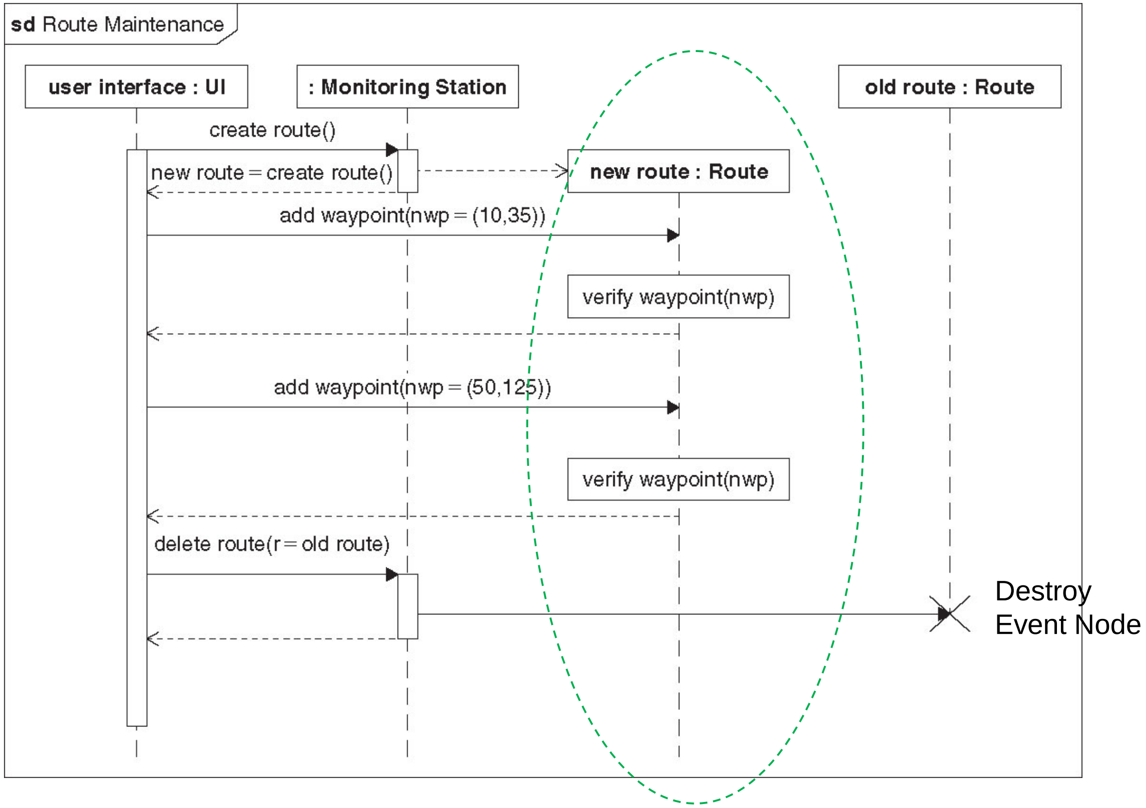
Weak Sequencing



Message can Trigger Execution

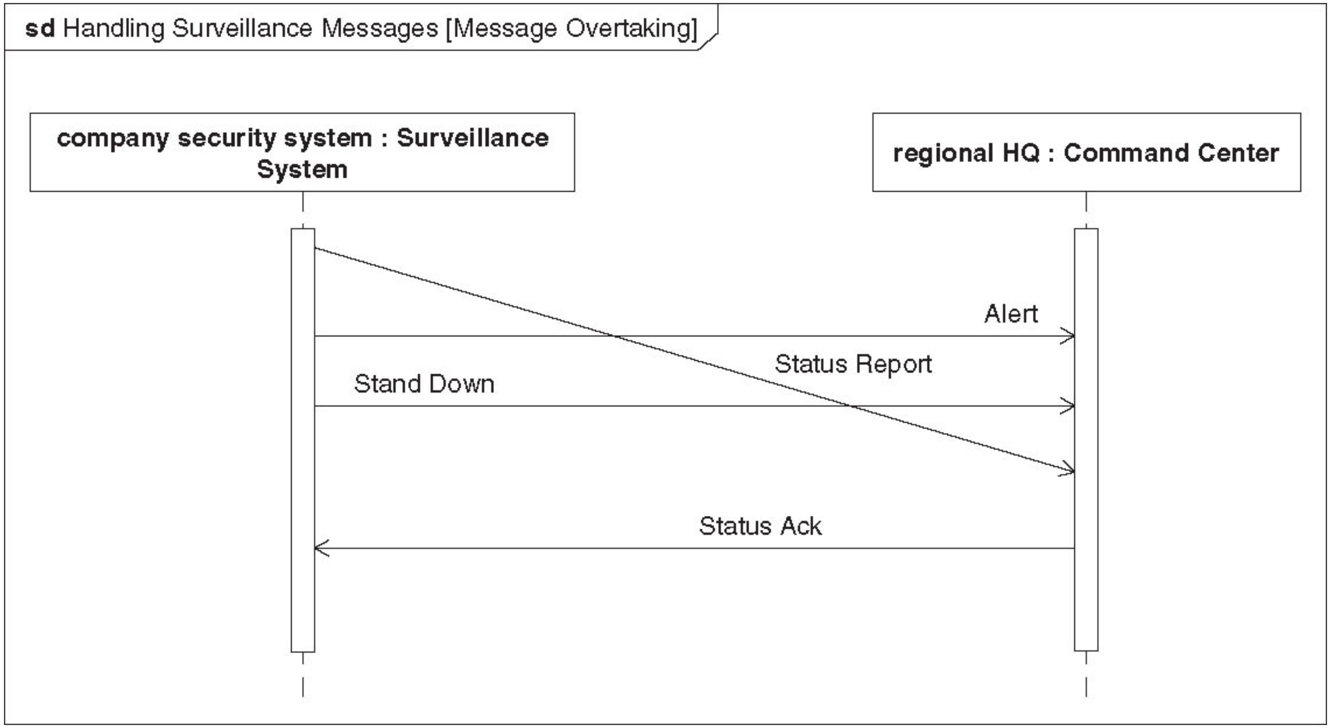

sd Camera Control [Simple Sequence with Activations]
security guard [Elvis] : Advanced Operator
company security system : Surveillance System
select camera(camera id = "CCC1")
current camera = camera id
get current status()
get status (current camera)
get status():"OK"
get current status():"OK"
pan camera(strength = "2")
get current status()
get status (current camera)
get status():"Moving"
get current status():"Moving"

Create and Destroy Messages

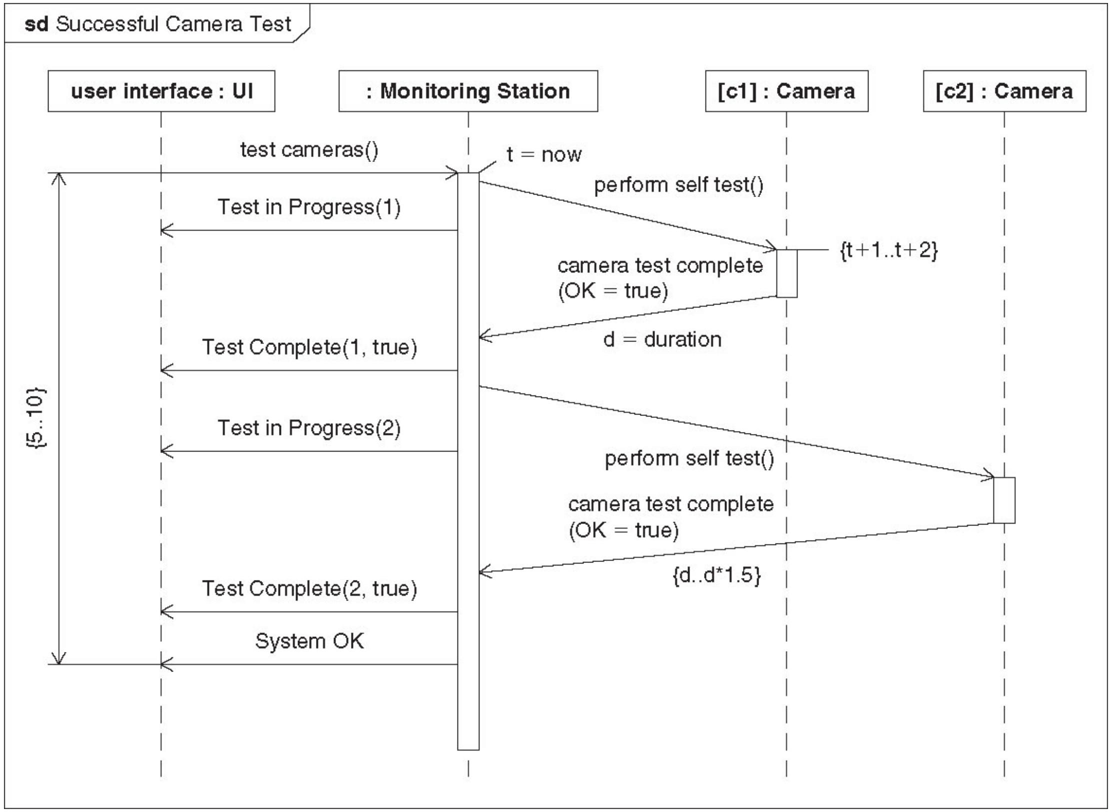


Methods/functions

Message Overtaking


sd Handling Surveillance Messages [Message Overtaking]
company security system : Surveillance System
regional HQ : Command Center
Alert
Status Report
Stand Down
Status Ack

Time on a Sequence Diagram

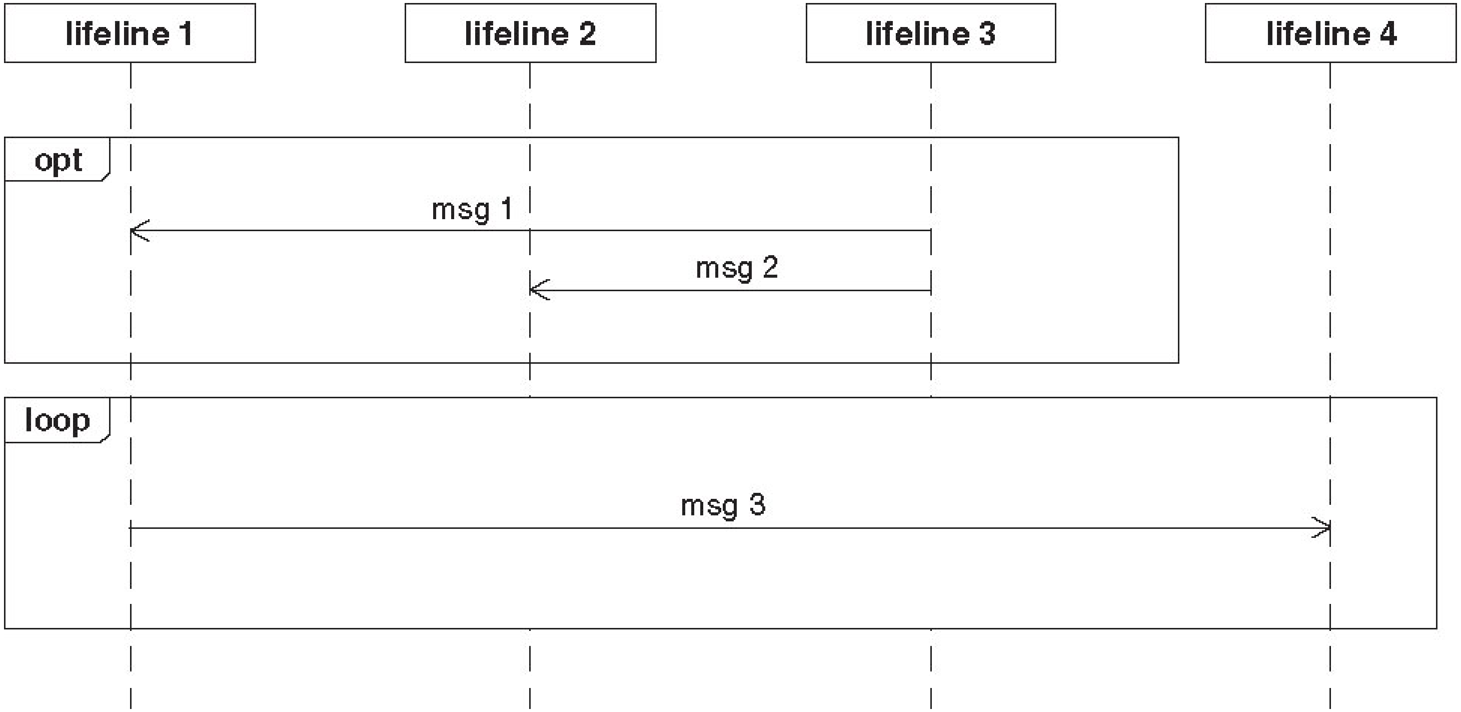


Modelling Complex Scenarios

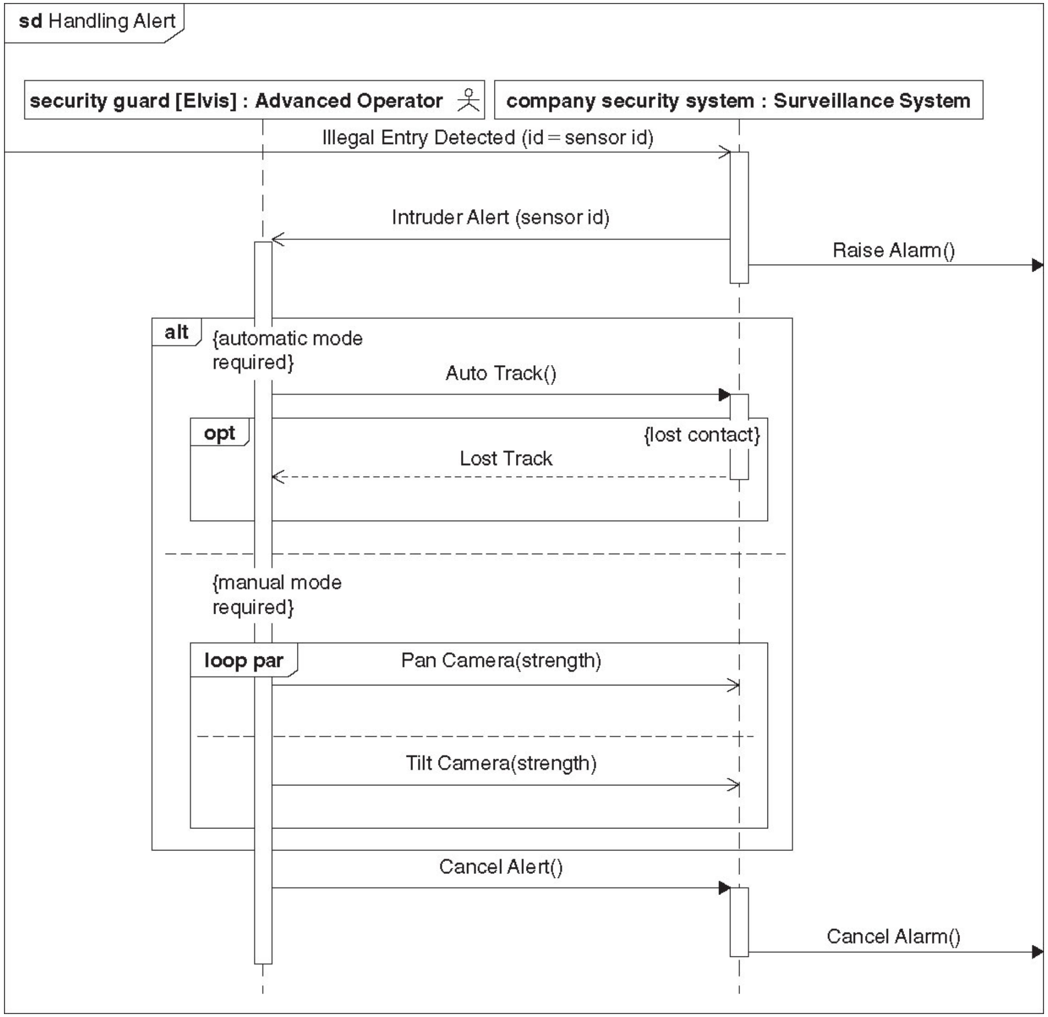
Interaction Operators

- Seq – Weak sequencing
- Par – Parallel, each following seq
- Alt/else – One selected based on guard. Has a choice between fragments
- Opt – unary operator (go/no-go)
- Loop – repeat fragment until constraint is met

Lifelines obscured if not used



Sequence Diagram

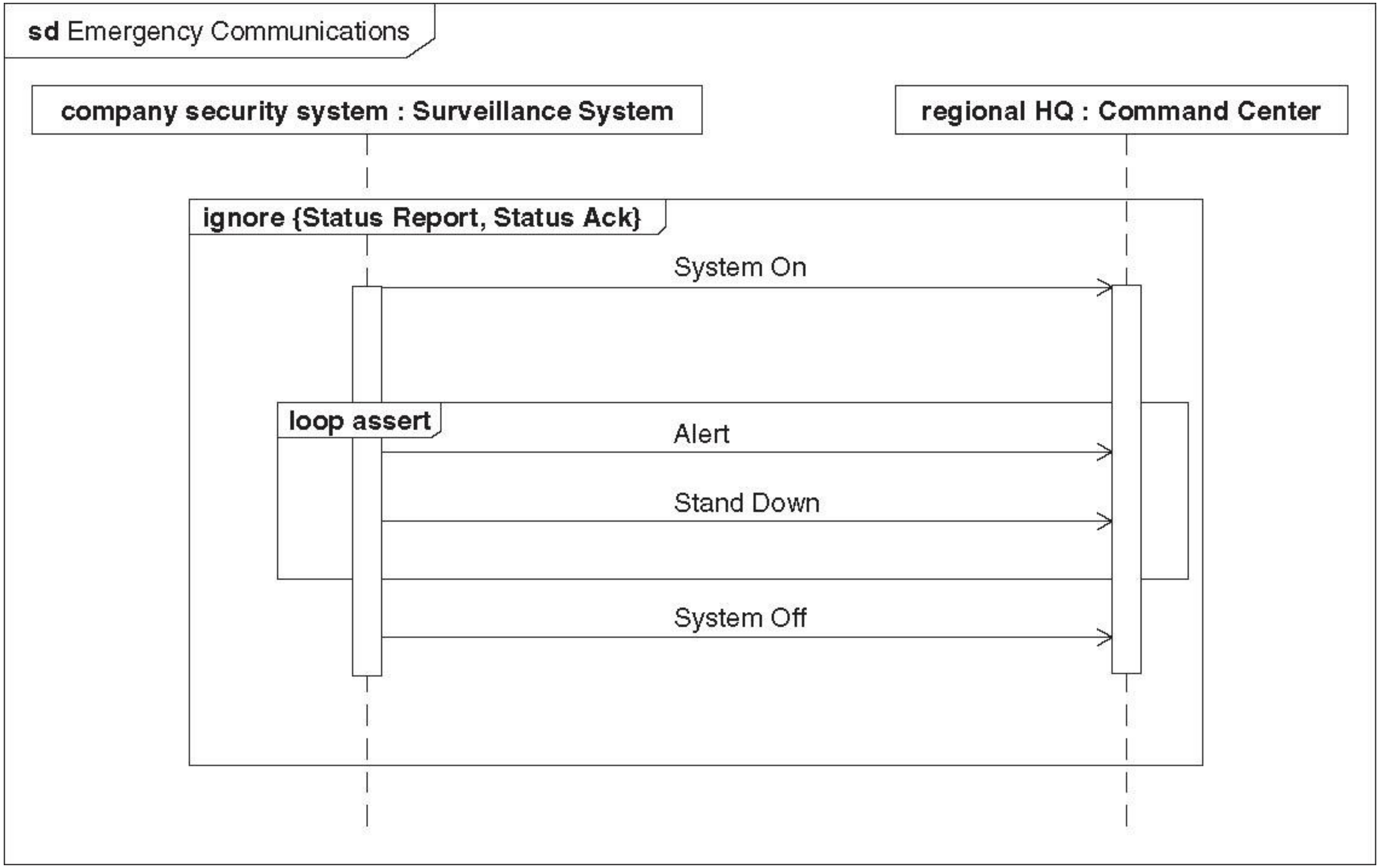

sd Handling Alert
security guard [Elvis] : Advanced Operator
company security system : Surveillance System
Illegal Entry Detected (id = sensor id)
Intruder Alert (sensor id)
Raise Alarm()
alt
{automatic mode required}
Auto Track()
opt
{lost contact}
Lost Track
{manual mode required}
loop par
Pan Camera(strength)
Tilt Camera(strength)
Cancel Alert()
Cancel Alarm()

More Interaction Operators

- Strict – like seq, but also affects receives
- Break – if satisfied, operand is executed instead of remainder of fragment
- Critical – indicates that operand must be performed with no interleaving

- Consider – only use messages from a specified set of operations/signals
- Ignore – do not consider messages from a specified set of operations/signals
- Assert – overrides consider and ignore operators within the assert's operand

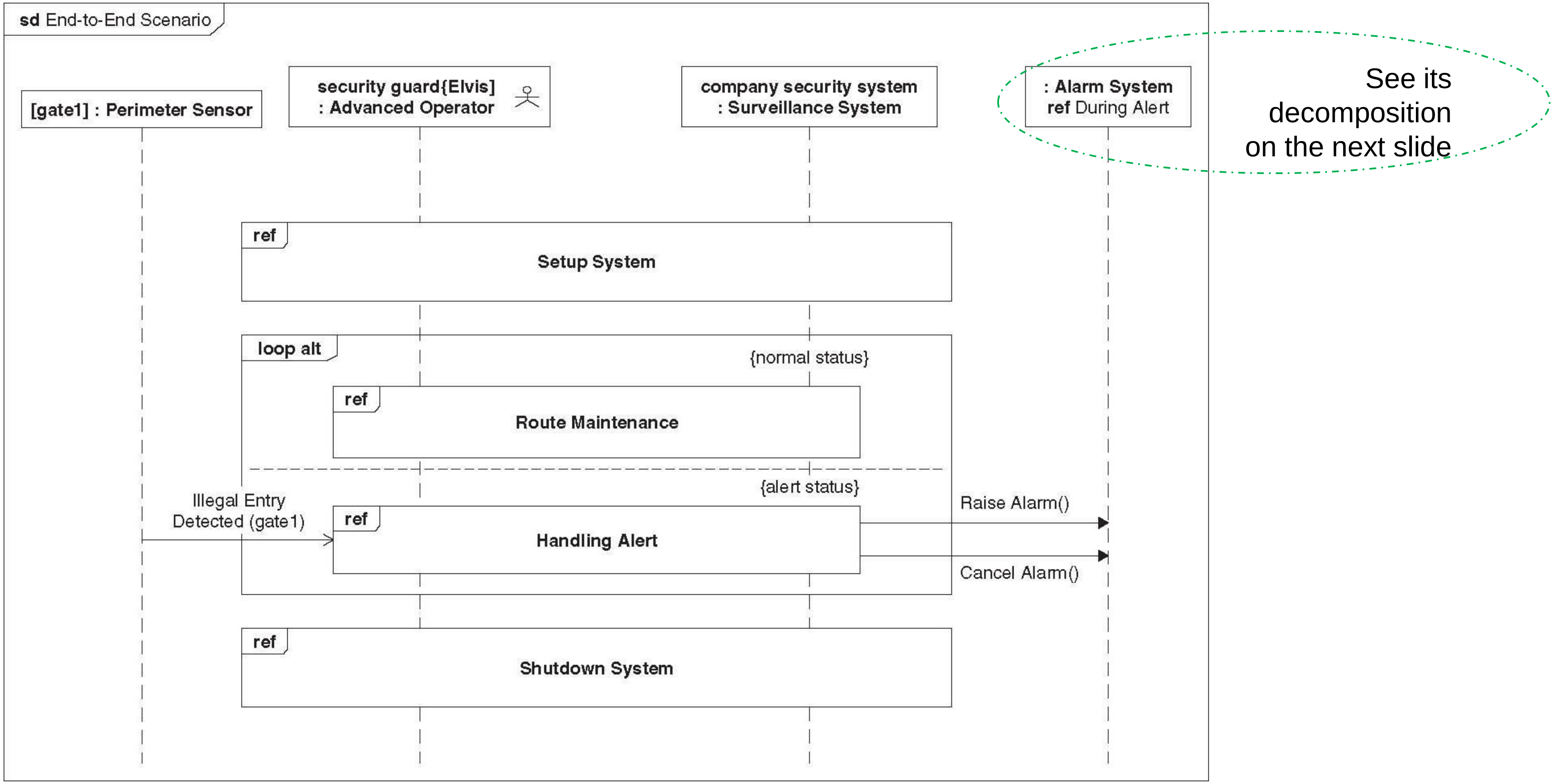
Consider/Ignore/Assert


sd Emergency Communications
company security system : Surveillance System
regional HQ : Command Center
ignore {Status Report, Status Ack}
System On
loop assert
Alert
Stand Down
System Off

Interaction References

- Interactions can reference previously defined interactions (interaction use) for:
  - Reuse; and
  - Scalability
- Gates used to show message exchange
  - Formal – gate on the called interaction; and
  - Actual – gate on the calling interaction
- Reference operands denoted as **ref**

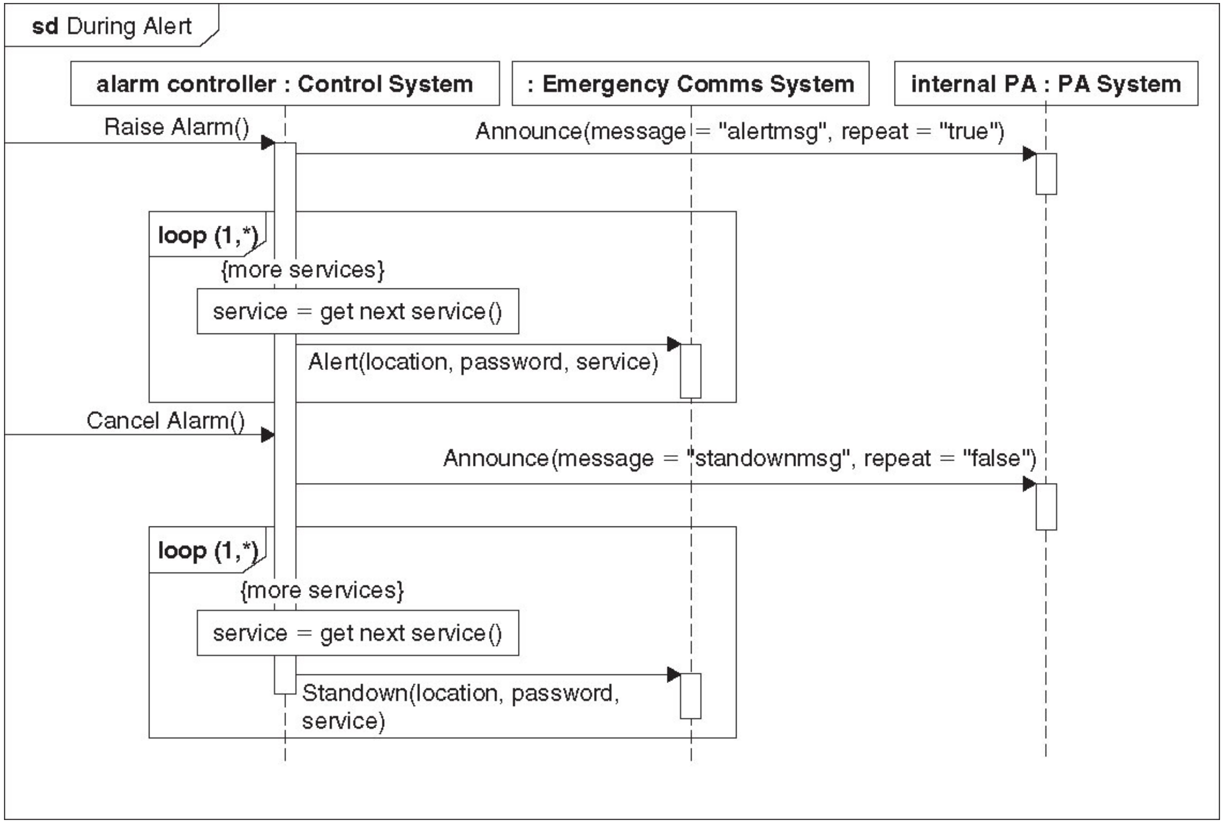
Reference Usage



See its decomposition on the next slide

Reference Usage

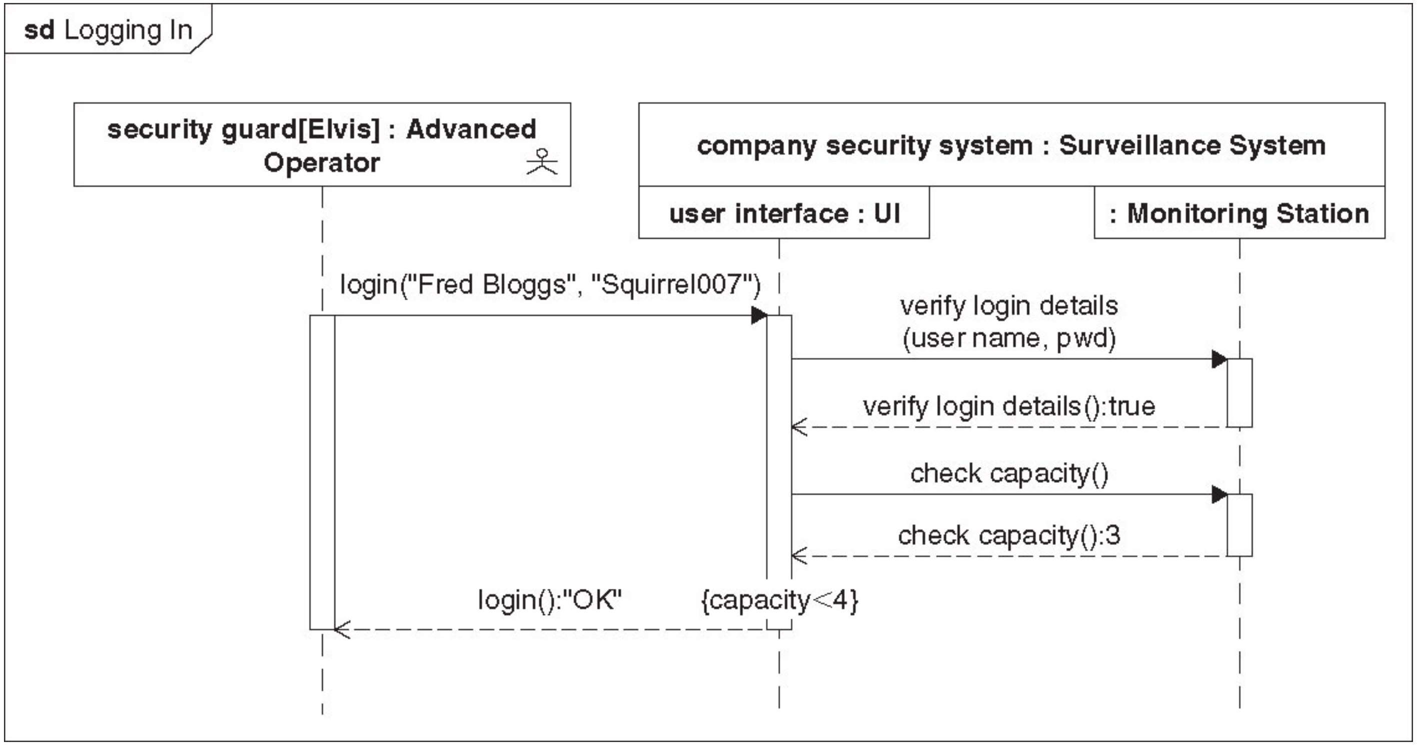
Interactions within the Alarm System


sd During Alert
alarm controller : Control System
: Emergency Comms System
internal PA : PA System
Raise Alarm()
Announce(message = "alertmsg", repeat = "true")
loop (1,*)
{more services}
service = get next service()
Alert(location, password, service)
Cancel Alarm()
Announce(message = "standownmsg", repeat = "false")
loop (1,*)
{more services}
service = get next service()
Standown(location, password, service)

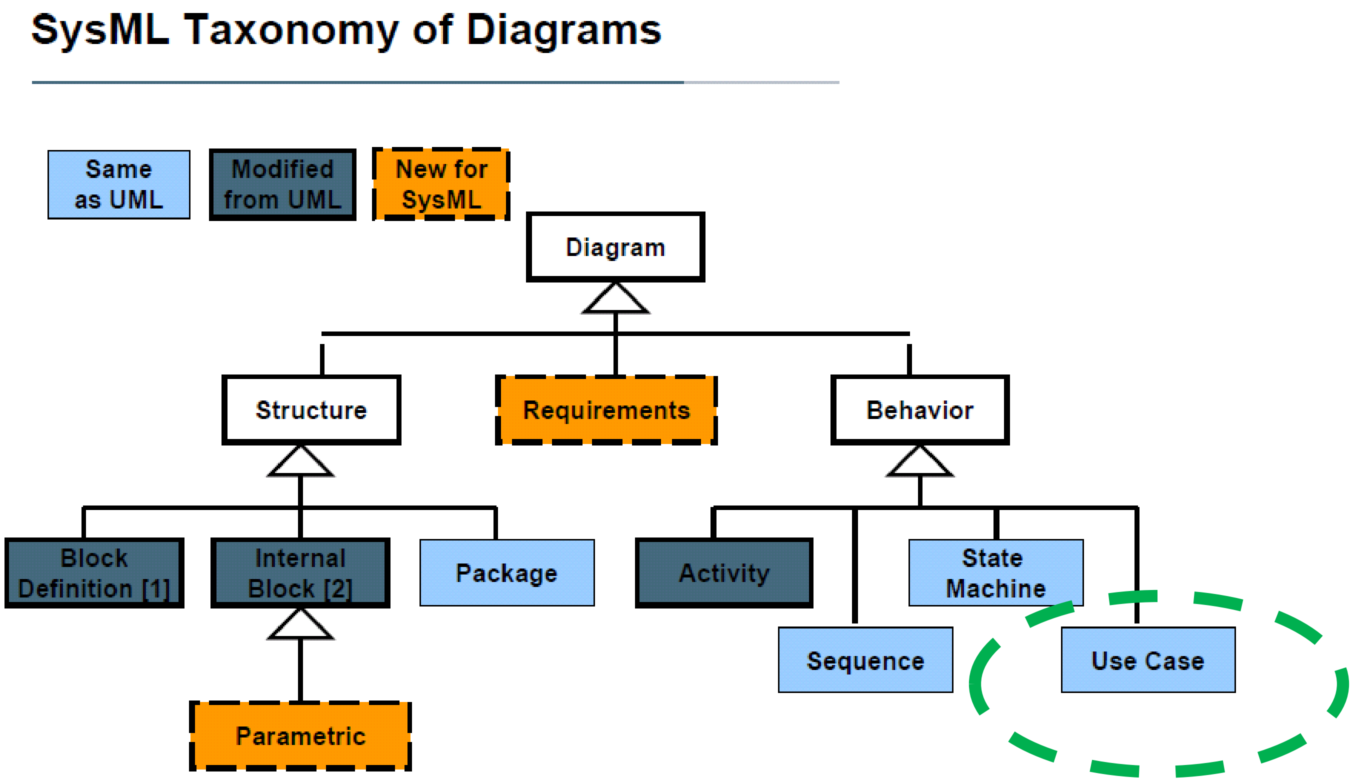
Reference Usage

Nesting of Lifeline Decomposition

Example – A *security guard* wishes to log into a *company security system*


sd Logging In
security guard[Elvis] : Advanced Operator
company security system : Surveillance System
user interface : UI
: Monitoring Station
login("Fred Bloggs", "Squirrel007")
verify login details (user name, pwd)
verify login details():true
check capacity()
check capacity():3
login():"OK"
{capacity<4}

Use Case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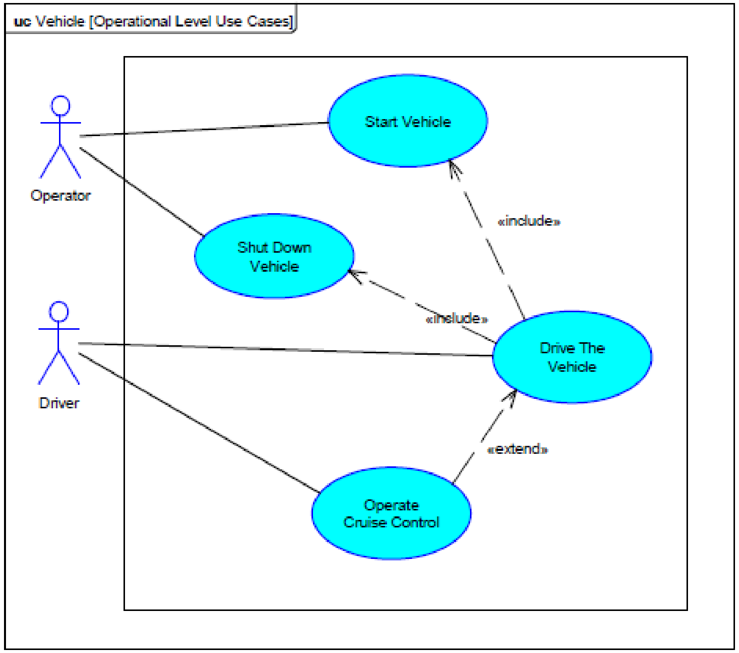
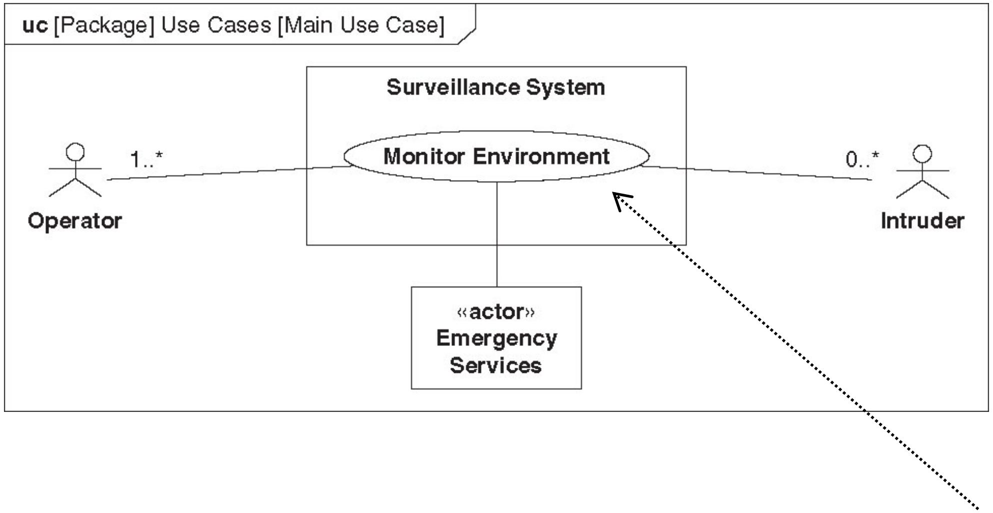
Use Case Diagram

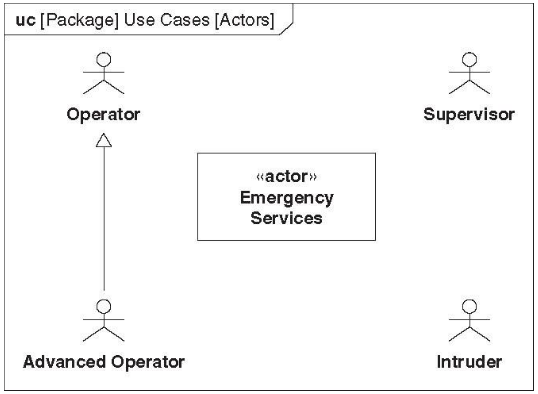
- UML Behavior Diagram
- Provides a means for describing functionality in terms of system usage by actors
- Typically used only at high levels
- Actors represent any external system that participates in the use of the system (human, organization, etc.)
- Typically shown as a stick figure with a name underneath



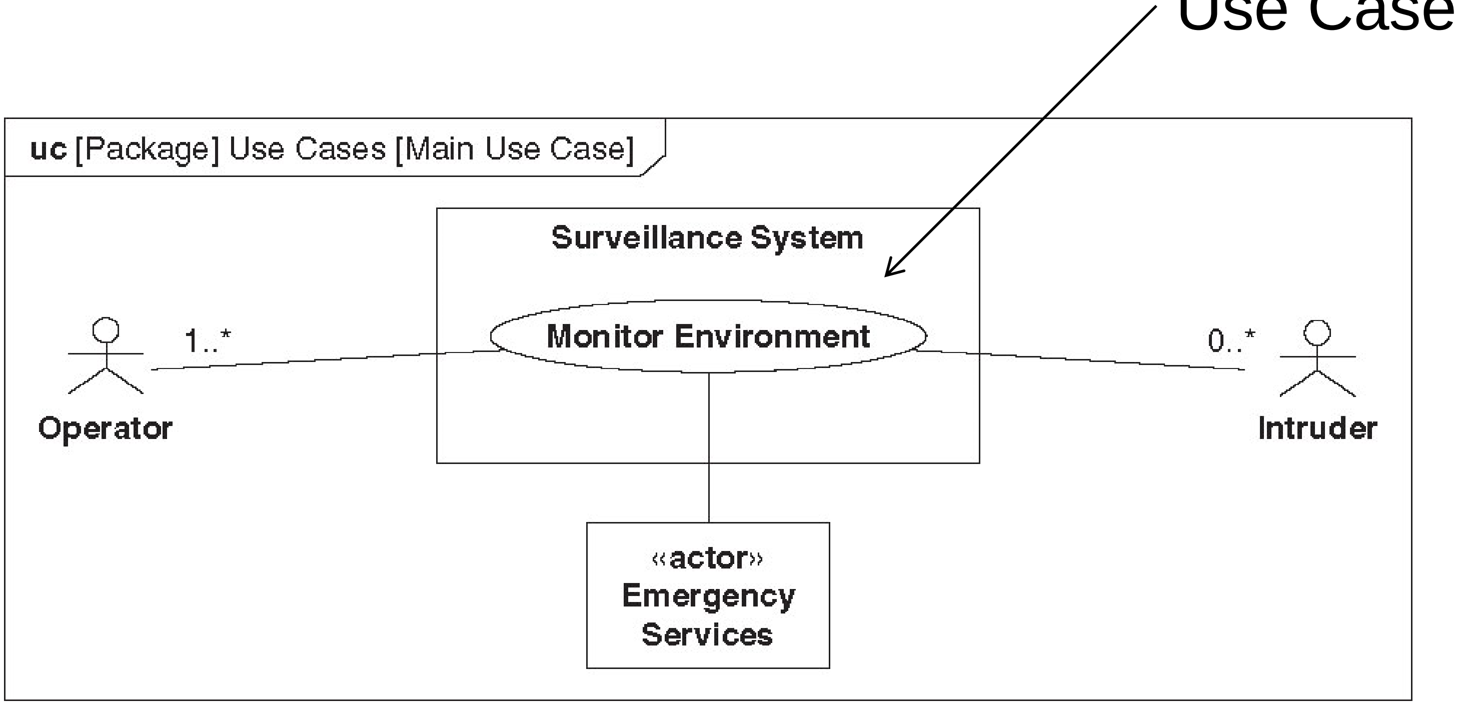
Use Case Diagram



Use Case



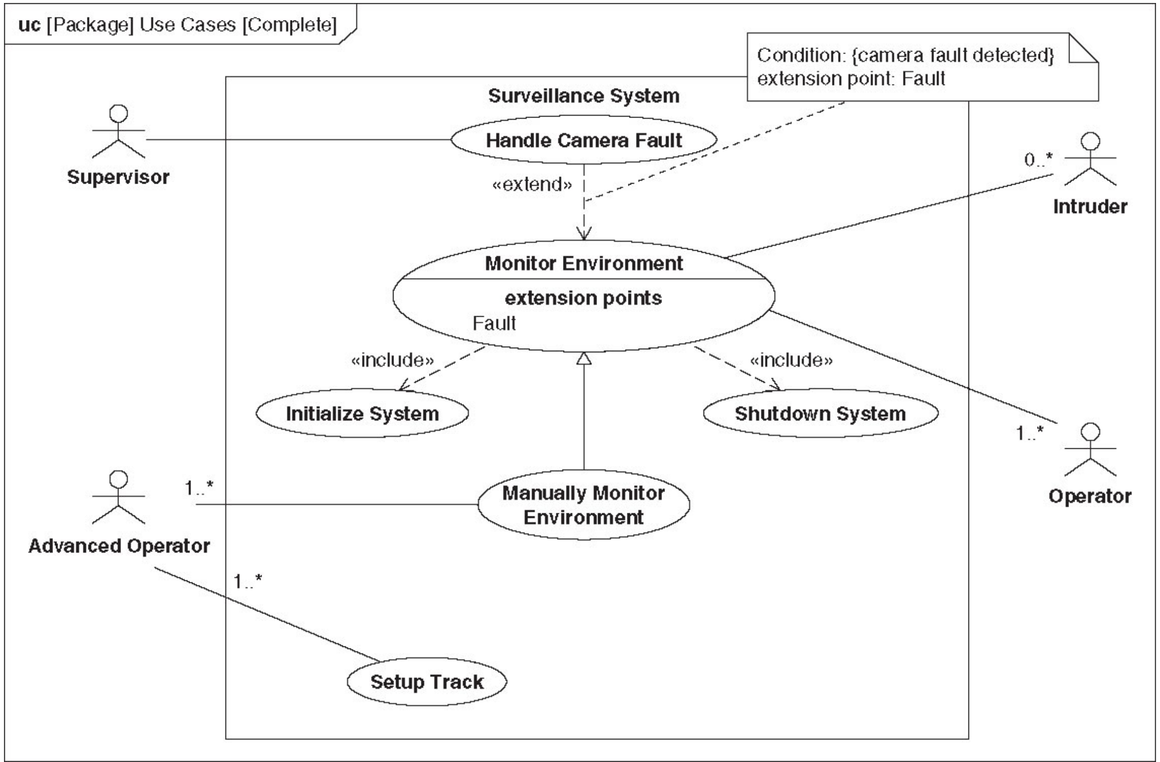
Use Case Diagram



Use Case

Use Case Relationships

- Inclusion – allows a base use case to include the functionality of another use case as part of its overall functionality when performed.
- Extension – a fragment of functionality that describes an exceptional behavior
  - Must specify extension point



Use Case Description

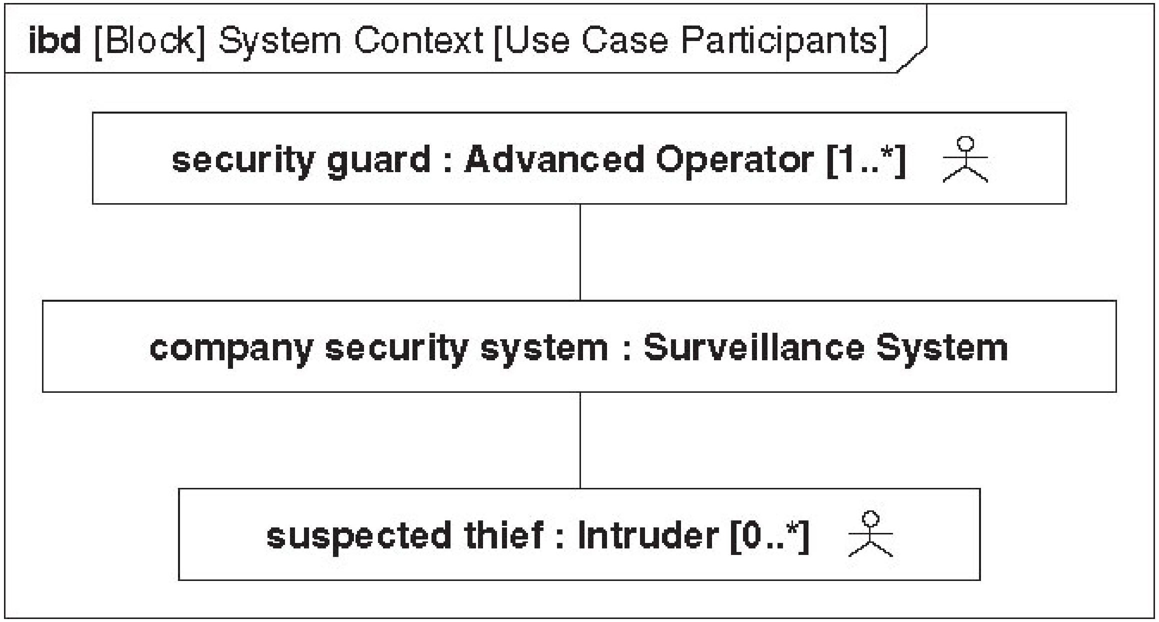
- Text based document to support use case definition
  - Preconditions: must be met to begin
  - Postconditions: must exist when completed
  - Primary flow: most likely scenario(s)
  - Alternate/exception flows: other scenario(s)

Elaborating Use Cases

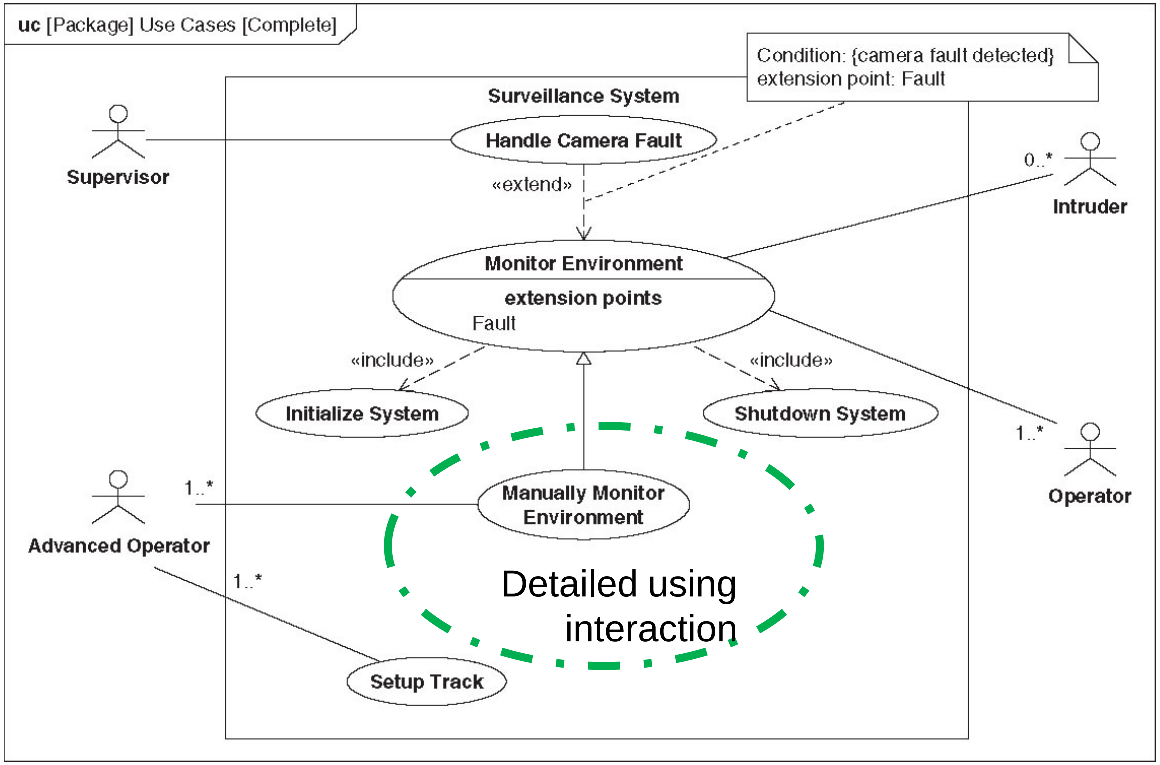
- Detailed Definition of a Use Case can be modelled with interaction, activities or stake machines:
  - **Interactions** are useful where a scenarios is largely message-based;
  - **Activities** are useful where the scenarios include considerable control logic, flow of i/p and o/p or algorithm that transform data;
  - **State machines** are useful when the interaction between the actors and the subject is asynchronous (event-based), not easily represented by an ordered sequence

Context Diagram

Essential to start detailed modelling with a Context Diagram


ibd [Block] System Context [Use Case Participants]
security guard : Advanced Operator [1..*]
company security system : Surveillance System
suspected thief : Intruder [0..*]

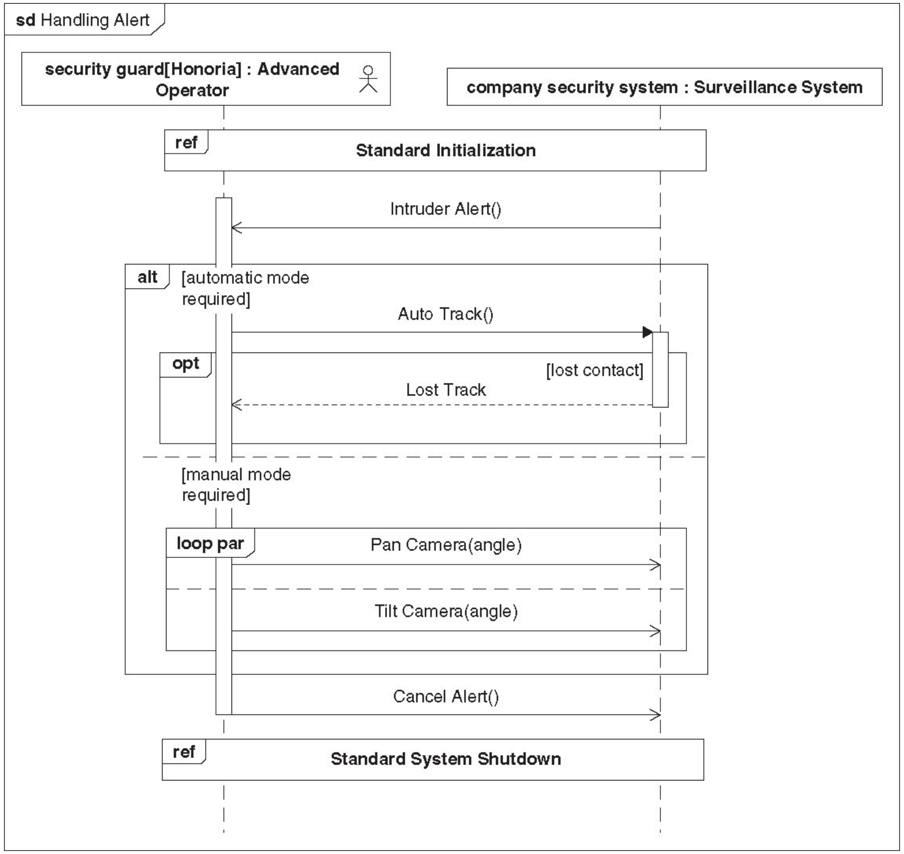
High-Level Use Case



Detailed using interaction

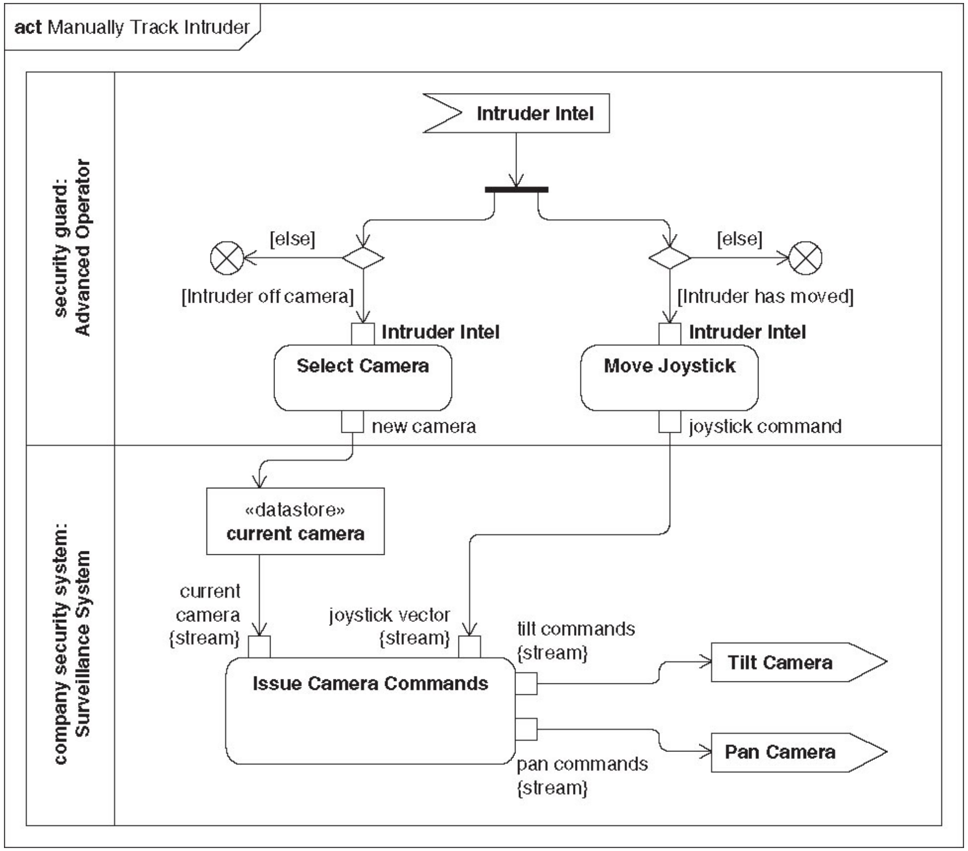
Detailed modelling of Use Case using Interaction

- Handling Alert of the *Manually Monitor Environment* use case



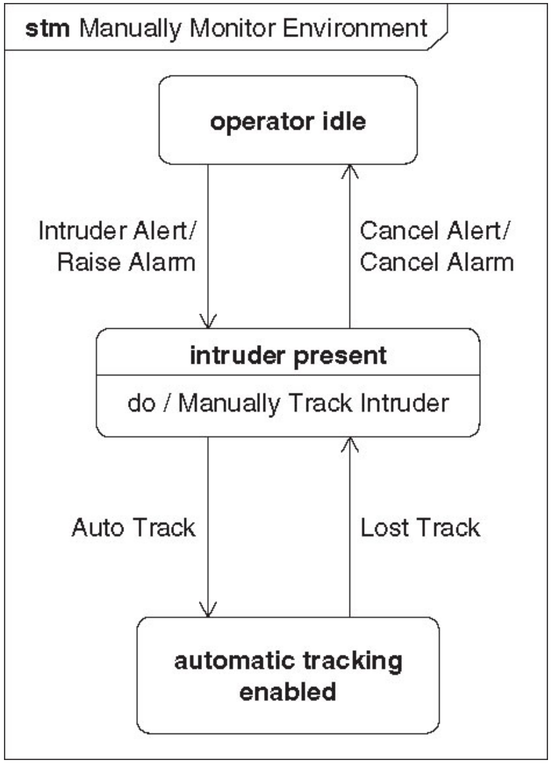
Detailed modelling of Use Case using Activity

- *Manual Track Intruder* activity of the *Manually Monitor Environment* use case



Detailed modelling of Use Case using State Machines

- Key states in the *Manually Monitor Environment* use case are: *operator idle, intruder present, automatic tracking enabled*
- Focus on states rather than messages.


stm Manually Monitor Environment
operator idle
Intruder Alert/ Raise Alarm
Cancel Alert/ Cancel Alarm
intruder present
do / Manually Track Intruder
Auto Track
Lost Track
automatic tracking enabled

Program Completed

Missouri University of Science & Technology