INF5120
”Modelbased System development”

Lecture 1: 15.01.2018
Arne-Jørgen Berre

arneb@ifi.uio.no and Arne.J.Berre@sintef.no
Welcome to INF5120
“Model based System development”

- Model based System Development - (with Platform based system development)
  - [http://www.uio.no/studier/emner/matnat/ifi/INF5120/](http://www.uio.no/studier/emner/matnat/ifi/INF5120/)

- Lecturers:
  - Arne-Jørgen Berre
  - Guest lecturers
  - Email: inf5120-forelesere@ifi.uio.no

- Collaboration with Software Engineering course at FAU - Florida Atlantic University, Boca Raton, Florida, USA – Professor Shiong Huang (Same Smart X project and use of IBM Cloud, IoT, Watson technology platform)
- Collaboration with Professor Øystein Haugen, Østfold University College, Halden (previous at SINTEF and UiO) – on Cyber Physical Systems and IoT

- Teaching Assistant responsible for Obligatory exercises:
  - TBD
  - Email: inf5120-oppgaver@ifi.uio.no
Course parts (16 lectures) - 2018

**Part I-a - (Introduction to Modeling):**
- **15/1 - Start**
- **1-15/1: Introduction to INF5120**

**Part I-b - (Introduction to Business Architecture and Business Modeling)**
- **2-22/1: Modeling structure and behaviour (UML and UML 2.0 and metamodelling)**
- **3-29/1: Business Modeling – BMC, LSC, VDML/VDMBee, (w/meta model) - (Business Model Canvas, Value Proposition, Lean Canvas)**

**Part II - (Modeling – Server side – Node-RED + THingML + Sensors/IoT/Cloud - and the Smart X project):**
- **4-5/2: Node-RED/IBM Bluemix/Cloud – getting started - establish Oblig groups**
- **5-12/2: BPMN process, UML Activ.Diagrams, CJML, Workflow modelling value networks (for Oblig 1) + Node-RED**
- **19/2 - Oblig 1: Smart X – Business Architecture – Groups - Individual- 10%**
- **6-19/2: Node-RED + Sensors (for Oblig 2)**
- **7-26/2: Node-RED + ThingML, ThingML language development, Database modelling (NoSQL)**
- **8-5/3: ThingML + server side + Service Modeling + Process Modeling ArchiMate**
- **12/3 - Oblig 2: Smart X – Node-RED server side – 10%**

**Part Iii - (Modeling – UI – Client side – Apps + EA/ArchiMate)**
- **9-12/3: UI Start lecture – incl. CJML and ArchiMate (for Oblig 3)**
- **10- 19/3: UI App development with IBM Cloud – refer IFML/WebRatio**
- **EASTER – 26/3 and 2/4**
- **11- 9/4 UI – Server – EA with ArchiMate - discussion/presentation**
- **16/4 - Oblig 3: Smart Building – UI – Client side – 10%**

**Part IV - (MDE – Creating Your own Domain Specific Language – Eclipse, Xtext/SIRIUS):**
- **12-16/4: MDE with Xtext and SIRIUS**
- **13-23/4: MDE transformations, Non Functional requirements**
- **14-30/5: Guest lecture**
- **15-7/5: Guest lecture**
- **14/5 - Oblig 4 - Your own Domain Specific Language – (DSL-x) - 10%**
- **16-14/5: Summary of the course**

Mandag 21/5 – PINSE

17-28/5: Conclusions, Previous exams – group collaborations Preparations for the Exam by old exams (+ 4/6, + 11/6)

**15/6: Exam (4 hours), Friday June 15th, 1430-1830 - ) - 60%**
EBDVF 2017: Future directions to Data-Driven Innovation and Artificial Intelligence

The European Big Data Value Forum 2017, with the scope "Trusted AI in Smart Industry", ended in Versailles with the participation of over 800 participants on average per day (1200 registrations for 3 days).

Challenges and future directions in data-driven & artificial intelligence research and innovation have been discussed and analysed among key players and stakeholders of the Big Data Value Ecosystem. Key technological and societal aspects of trust and transparency for human-centred data-driven innovation were addressed.

Digitising European Industry Stakeholder Forum 2018
BDVA TF6 Technical Priorities

TF5: Policy & Societal
- TF6: Technical
  - TF6-SG1: Data Management
  - TF6-SG2: Data Processing Architectures
  - TF6-SG3: Data Analytics
  - TF6-SG4: Data Protection and Pseudonymisation Mechanisms
  - TF6-SG5: Advanced Visualisation and User Experience
  - TF6-SG6: Standardisation

TF6: Technical
- TF7: Application
  - TF7-SG1: Emerging Application Areas
  - TF7-SG2: Telecom
  - TF7-SG3: Healthcare
  - TF7-SG4: Media
  - TF7-SG5: Earth observation & remote sensing
  - TF7-SG6: Smart Manufacturing Industry
  - TF7-SG7: Mobility and Logistics
  - TF7-SG8: Smart Cities

TF7: Application
- TF8: Business
  - TF8-SG1: Data entreprenuers (SMEs and startups)
  - TF8-SG2: Transforming traditional business (Large Enterprise)
  - TF8-SG3: Observatory on Data Business Models

TF8: Business
- TF9: Skills and Education
  - TF9-SG1: Skill requirements from European industries
  - TF9-SG2: Analysis of current curricula related to data science
  - TF9-SG3: Liaison with existing educational projects

Dr. Arne J. Berre
SINTEF Digital
BDV – Big Data and Analytics/Machine Learning Reference Model

Data Visualisation and User Interaction
Data Analytics
Data Processing Architectures
Data Protection
Data Management
Cloud and High Performance Computing (HPC)
Things/Assets, Sensors and Actuators (Edge, IoT, CPS)
Big Data Value Reference Model

Applications/Solutions: Manufacturing, Health, Energy, Transport, BioEco, Media, Telco, Finance, EO, SE, ...

Big Data Priority Tech Areas

- Big data Types & semantics
  - Struct data/BI
  - Time series, IoT
  - Geo Spatio Temp
  - Media Image Audio
  - Text NLP, Genom
  - Web Graph Meta

Data Processing Architectures and Workflows
- Batch, Interactive, Streaming/Real-time

Data Analytics
- Descriptive, Diagnostic, Predictive, Prescriptive
- Machine Learning and AI, Deep Learning, Statistics, HYBRID ANALYTICS (Optim/Simulation)

Data Visualisation and User Interaction
- 1D, 2D, 3D, 4D, VR/AR

Data Protection,
- Anonymisation, ...

Data Management
- Collection, Preparation, Curation, Linking, Access, Sharing – Data Market / Data Spaces
- DB types: SQL, NoSQL (Document, Key-Value, Column, Array, Graph, ...)

Cloud and High Performance Computing (HPC)

Things/Assets, Sensors and Actuators (Edge, Fog, IoT, CPS)

Communication and Connectivity, incl. 5G

CyberSecurity and Trust

Development - Engineering and DevOps

Data sharing platforms, Industrial/Personal

Relevant technology platforms:
IBM Cloud/Bluemix/Watson, MS Azure/Machine learning, Amazon Web services, Apache Hadoop.

www.bdva.eu
Course INF5120 – Institute for Informatics, UiO – Model-based and Platform-based System Development – Every Monday, 1400-1700 – Starting Monday January 15th, 2018
Contact: Arne.J.Berre@sintef.no, SINTEF Digital, Software and Service Innovation, Smart Data

› Business Architecture – Modeling with Business Model Canvas, Lean Startup Canvas and VDML – Value Delivery Modeling Language, Enterprise Architecture with TOGAF and ArchiMate 3.0 modeling

› Project on Smart Home/Smart Cities, Industry 4.0 – using IoT Platforms – with usage of IBM Cloud, IBM Bluemix, IBM Watson IoT, and comparisons with Microsoft Azure, Amazon Web services, Kongsberg KognifAI, DNV Veracity, GE Predix, …

› System Architecture – Modeling HW/SW – with sensors/actuators, Raspberry Pi

› Software Architecture – Modeling UI with IFML, Analytics/Machine Learning and Service Composition with Microservices and SoaML, Big Data and Databases with UML – SQL and NoSQL databases

› Software Engineering with Agile Development (Scrum/Lean/Kanban)

› Model-driven Engineering – Creating and using Domain Specific Languages – Node-RED, ThingML, CloudML, …

› StartUp project – Group project from Business Idea to Minimum Viable Product (MVP) during the course
4 parts of the course

- Enterprise Architecture and Business Architecture – Modeling context and Requirements – with BMC, LSC, VDML, TOGAF and ArchiMate 3.0 and requirements engineering

- MDE-Platform-Server: (System and Software Architecture Engineering - Model Driven system architecture and realization – with IBM Cloud/BlueMix/Watson technology platform – with Node-RED, ThingML, CloudML, …)

- MDE-Platform-Client: (Analytics, Processing and User Interaction with Visualisation)

- MDE-DSL (Model Driven Engineering) – Modeling of Structure and Behaviour in "systems"- Creation of domain specific languages and editors
Course components

Enterprise Architecture
Business Architecture
(BMC, LSC, VDML)

Software/System Architecture
Engineering for Technology
Platforms (Node-RED, ThingML Server -2)

Software Architecture with
Analytics and Visualisation
client -1

Model Driven
Engineering –
New DSL -3

"Smart X"
3+1 OBLIGS
Update to the course in 2018

- We have a project focus on "Smart X" with focus on Platform based development with Internet of Things for Smart Home – and also for applicable for Industry 4.0.

- We will use Business Model Canvas and Lean Startup Canvas in combination with VDML (Value Delivery Modeling Language).

- We will introduce a stronger focus on IoT/Cyber Physical System/Big Data support through the use of emerging platforms – with IBM Cloud BlueMix as an example – with Node-RED, Watson IoT, - and also ThingML domain specific language - and supporting Metamodels.

- We will reduce the focus on App/Web Porta/UI development with the IFML/WebRatio and also have UIs with AngularJ, React Native, ....

- The core MDE part will still focus on the Modeling of Strucure and Behaviour in "systems" including the creation of Model Driven Engineering tools – and the creation of tool support for new domain specific languages.
Obligs

- Partially individual, partially group - in multiple, incremental parts

- Oblig 1, 2, 3 and 4 "Smart X and DSLs" – your "own" company to develop an IoT solution with sensor system control for Smart Homes – will be presented in more detail on January 30th

- Oblig 1, 2, 3 and 4 – Evaluation will count as part of your final grade (10+10+10+10 = 40%)
Architecture for "Smart X" project
Spring 2018

- Eclipse and open-source tooling
- CPS Lab with sensors and actuators
- Smart phones
- Database
- Sensor
- Actuator
- Collaboration: Inter-discipline, Inter-Institution, Internet
- Intelligent Home
- Student involvement
Technology Platform:
Node-RED, Raspberry Pi, IBM Cloud/Bluemix/Watson IoT

- IoT Hub,
  - Analytics
  - Visualisation
  - Apps

ThingML
Book on Model-Based system development

- Model-Driven Software Engineering in Practice
- ISBN 978-1-60845-882-0
- 2012, 166 pages (new version 2017)
- Marco Brambilla, Jordi Cabot and Manuel Wimmer
UML 2.0

- UML 2.0 and SysML Background and Reference material
- See www.uml-forum.com/specs.htm

- Also at OMG:
- http://www.omg.org/uml/ (UML)
- http://www.omg.org/mda/ (MDA)
- http://www.omg.org/cwm/ (MOF, XMI, CWM)
UML 2.0 recommended books:

UML 2.0 in a Nutshell
by Dan Pilone (Author), Neil Pitman (Author)

The Unified Modeling Language User Guide
(G, Booch, J. Rumbaugh, Jacobsson)
Requirements for the course

- Student at UIO

- Only assumption is basic knowledge of UML and Java (but not necessarily UML 2.0) – we will use Model-based tools/languages – and JavaScript.

- Links to other courses on software engineering, entrepreneurship, user interaction etc.
Exam

- Oblig 1,2,3,4 (40%)
- Case-based (ref. earlier exams) (60%)
- All written material can be used
- 4 hours
- Planned: Friday June 13th, 2018, 1430-1830 (4 hours)
- The grades from the OBLIGS count 40% as part of the final grade of the course
OMG Model-Driven Architecture (MDA)

www.omg.org/mda
Automation in Software Development

Requirements

Manually implement

Source in a general-purpose language, e.g., Java or C++

Compile

Implementation

Requirements

Manually implement

Source in domain-specific language (DSL)

Compile

Implementation

Requirements

Manually implement

High-level spec (functional and nonfunctional)

Compile

Implementation

Implement with Interactive, automated support

Source in domain-specific language (DSL)

Compile

Implementation

Source in domain-specific language (DSL)

Compile

Implementation

(may generate code in Java or C++)
MDA
CIM, PIM
and
PSM/Code

Computational
Independent
Model

CIM

ATL

Platform
Independent
Model

PIM

MOFScript

Platform
Specific
Model/Code

PSM

ADM

ADM

BPEL, WSDL, XML, XPDL,
OWL-S, WSML, WSDL-S

BPMN, POP*, ARIS,
ArchiMate,
GERAM, GRAI, Zachman,
UEML, B.Rules

BPDM, SBVR,
EDOC, UPMS,
PIM4SOA, ODM

UML profiles and
metamodels for Java
JEE, BPEL, WSDL,
XML, XPDL,
OWL-S, WSML, WSDL-S

Code, Java JEE,
.....
Which Modeling languages will you learn?

- UML 2.0 – what is new in version 2
- VDML – Value Delivery Modeling Language – with VNA
- TOGAF with ArchiMate 3.0
- Node-RED application workflow (not a standard)
- ThingML (State machine language for IoT, not standard)
- SoaML – SOA Modeling Language
- MDA – Model Driven Architecture
- BPMN 2.0 – Business Process Modeling Notation
- BMM _ Business Motivation Model
- SysML – Systems Engineering Modeling Language
- QVT, MOF2Text – Query, View, Transformation

See [www.omg.org](http://www.omg.org)
Which tools/environments will you learn?

- WebRatio - IFML for Web and Mobile Apps
- Agile team support – Symphonical/Someone, Scrumwise
- BMI – Business Model Innovation/Generation - Strategyzer
- Balsamiq – UI Mockups – for further UI modeling
- UML and BPMN modeling tools - MagicDraw
- AT ONE – Service Design – use of Smaply
- MagicDraw with UML and BPMN
- Eclipse EMF and XMI, Principles of GMF
- Sirius for Eclipse
- EPF/SPEM Software Process Modeler
- Overview of ATL, MOFScript, KerMeta, OpenArchitectureWare-OAW, …
Model Driven Engineering techniques

- Behaviour modeling: UML Behaviour modeling, BPMN
- Node-RED
- ThingML
- Enterprise Architecture – TOGAF – with ArchiMate 3.0
- Non functional modeling: OCL and Planguage
- Metamodeling and DSLs: EMF and Sirius
- Business Model Canvas and Value Proposition Canvas – VDMBee
- Scrum/Agile Project Management User stories and Use cases –
Software engineering practices and methods

- modelbased.net
- practices.modelbased.net

- A practices framework, SEMAT,  www.semat.org
Requirements and Agile development

The Agile Manifesto:  http://agilemanifesto.org/

Manifesto for Agile Software Development

We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:

Individuals and interactions over processes and tools
Working software over comprehensive documentation
Customer collaboration over contract negotiation
Responding to change over following a plan

That is, while there is value in the items on the right, we value the items on the left more.
Task management for teams made easy

Boost your team’s productivity, strengthen communication, improve efficiency and make worklife simpler!
Scrum – Scrumwise.com

The most intuitive Scrum tool you've ever tried
And it's lightning fast!

Try the instant demo
Just one click. No signup.

Loved by thousands of teams all over the world

Built for Scrum

Teams and roles
Backlog management
Release planning
Sprint planning

Task boards
Burndown charts
Kanban
Time tracking
What is Enterprise Modelling?

**Enterprise Modelling (EM)** is a capability for externalising, making and sharing enterprise knowledge.

EM tools can either be:
- used stand-alone to produce various kinds of model views,
- integrated as front-ends to other systems,
- part of an environment providing a contextual user-environment.
Why Enterprise Architecture?

How can I involve my people in improving the performance of the business?

How can I use best practices to ensure the success of the business?

How can I ensure that the IS technology helps the work of my people?

<table>
<thead>
<tr>
<th>VA Enterprise Architecture</th>
<th>DATA What</th>
<th>FUNCTION How</th>
<th>NETWORK Where</th>
<th>PEOPLE Who</th>
<th>TIME When</th>
<th>MOTIVATION Why</th>
<th>Based on work by John A. Zachman</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCOPE (CONTEXTUAL)</strong></td>
<td>Things Important to the Business</td>
<td>Processes Performed</td>
<td>Business Location</td>
<td>Important Organizations</td>
<td>Events Significant to the Business</td>
<td>Business Goals and Strategy</td>
<td>Planner</td>
</tr>
<tr>
<td>Planner</td>
<td>Entity = Class of Business Thing</td>
<td>Function = Class of Business Process</td>
<td>Node = Major Business Locations</td>
<td>People = Major Organizations</td>
<td>Time = Major Business Event</td>
<td>Ends/Mean = Major Business Goals</td>
<td>Planner</td>
</tr>
<tr>
<td><strong>SYSTEM MODEL (LOGICAL)</strong></td>
<td>Logical Data Model</td>
<td>Application Architecture</td>
<td>Distributed System Architecture</td>
<td>Human Interface Architecture</td>
<td>Processing Structure</td>
<td>Business Rule Model</td>
<td>Designer</td>
</tr>
<tr>
<td><strong>TECHNOLOGY MODEL (PHYSICAL)</strong></td>
<td>Physical Data Model</td>
<td>System Design</td>
<td>Technology Architecture</td>
<td>Presentation Architecture</td>
<td>Control Structure</td>
<td>Rule Design</td>
<td>Builder</td>
</tr>
<tr>
<td>Builder</td>
<td>Ent = Segment/Table Rel = Pointer/Key</td>
<td>Proc = Computer Function I/O = Data Elements/Set</td>
<td>Node = Hardware/Software Link = Line Specifications</td>
<td>People = User Work = Screen Format</td>
<td>Time = Execute Cycle = Component Cycle</td>
<td>End = Condition Means = Action</td>
<td>Builder</td>
</tr>
<tr>
<td><strong>DETAILED REPRESENTATIONS (OUT-OF-CONTEXT)</strong></td>
<td>Data Definition</td>
<td>Program</td>
<td>Nework Architecture</td>
<td>Security Architecture</td>
<td>Timing Definition</td>
<td>Rule Design</td>
<td>Sub-Contractor</td>
</tr>
<tr>
<td>Sub-Contractor</td>
<td>Ent = Field Rel = Address</td>
<td>Proc = Language Statement I/O = Control Block</td>
<td>Node = Addresses Link = Protocols</td>
<td>People = Identity Work = Job</td>
<td>Time = Interrupt Cycle = Machine Cycle</td>
<td>End = Sub-Condition Means = Step</td>
<td>Sub-Contractor</td>
</tr>
<tr>
<td><strong>FUNCTIONING ENTERPRISE</strong></td>
<td>Data</td>
<td>Function</td>
<td>Nework</td>
<td>Organization</td>
<td>Schedule</td>
<td>Strategy</td>
<td></td>
</tr>
<tr>
<td>Ent = Rel = I/O =</td>
<td>Proc =</td>
<td>Node =</td>
<td>People =</td>
<td>Time =</td>
<td>End =</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DATA What**

**FUNCTION How**

**NETWORK Where**

**PEOPLE Who**

**TIME When**

**MOTIVATION Why**
# Zachman with OMG standards

<table>
<thead>
<tr>
<th>Scope (Contexts)</th>
<th>Business (Concepts)</th>
<th>System (Logic)</th>
<th>Technology (Physics)</th>
<th>Component (Assemblies)</th>
<th>Operation (Instances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of things important to business — SBVR</td>
<td>SBVR</td>
<td>Logical Data Model — ODM, IFML, IMM (CWM)</td>
<td>Physical Data Model — IMM (CWM), UML</td>
<td>Data Definition — IMM (CWM), UML</td>
<td>Data</td>
</tr>
<tr>
<td>VDM</td>
<td>Workflow Model — OSM, BPMN, CMPM</td>
<td>Human Interface Architecture — BPMN, CMPM</td>
<td>Presentation Architecture</td>
<td>Security Architecture</td>
<td>Organization</td>
</tr>
<tr>
<td>List of events/cycles important to the business — DTFV</td>
<td>List of business goals/strategies — BMM</td>
<td>Business Rule Model — SBVR</td>
<td>Business Plan — SBVR</td>
<td>Rule Definition — SBVR</td>
<td>Strategy</td>
</tr>
</tbody>
</table>
A **system** is a part of the real world which we choose to regard as a whole, separated from the rest of the world during some period of consideration.

A whole that we choose to consider as a collection of objects, each **object** being characterized by **attributes** and by **actions** which may involve itself and other objects.
ArchiMate 3.0
Business Model Generation

Written by Alexander Osterwalder & Yves Pigneur
Co-created by an amazing crowd of 400+ practitioners from 45 countries
Designed by Alan Smith, The Design Garage

> 1 million copies sold

Generación de modelos de negocio

Alexander Osterwalder & Yves Pigneur

30 languages
Business Model Innovation

The Business Model Canvas
Strategyzer (Osterwalder)
Business Model Canvas and Value Proposition Canvas Resources

- [www.strategyzer.com](http://www.strategyzer.com)
- BizCanvas App for the iPad
- …
A Business Model describes the rationale of how an organization creates, delivers and captures value.
Reference examples in the course

- Concierge: A company with a system/service that offers advice and recommendations to people with respect to current and upcoming events, concerts, exhibitions etc.

- TravelAdvisor: A company with a system/service that offers advice and booking possibilities to travelers

- Senselt: UV sensor measurements (from the course of 2015)

- BioCaching: Citizen Science for Biodiversity (2016)

- Project 2017: Smart Building
Senselt
You're holding more than a book, it's the first step to design, test and deliver what really matters for your customers.

Value Proposition Design

By Alex Osterwalder, Yves Pigneur, Greg Bernarda, & Alan Smith
Designed by Trish Papadakos

From the team behind Business Model Generation, the global bestseller of over 1 million copies in 30+ languages

Strategyzer

October, 2014
Value Proposition Canvas

Value offer (Opportunity)

Value needs (Requirements)
Value Proposition Canvas

Value Proposition Map

- Hotel reservation
- Profile based recommendations
- Online selection
- Ensure early arrival rooms
- Ensure rooms next to each other

Gain Creators
- Family rooms
- Business room wide
- Define internet speed groups

Pain Relievers

Customer Segment Profile

- Families
  - Room for family
  - Business rooms
  - Rooms not in order
  - Room are far apart

Gains
- Holiday travel

Jobs
BPMN and UML

- BPMN
- UML 2.0
What is BPMN (Business Process Modeling Notation)?

- BPMN is flow-chart based notation for defining Business Processes.

- BPMN is an agreement between multiple modeling tools vendors, who had their own notations, to use a single notation for the benefit of end-user understand and training.

- BPMN provides a mechanism to generate an executable Business Process (BPEL) from the business level notation.
  - A Business Process developed by a business analyst can be directly applied to a BPM engine instead of going through human interpretations and translations into other languages.
BPMN example

Telecom and Informatics

Patient

1) I want to see doctor

Receptionist

2) Are you available? 3) I'm available 4) I'll book you

Doctor

8) Pick up your medicine and you can leave

10) Here is your medicine

I'm sick

SINTEF
UML Activity model (or BPMN)

Activity model

Interaction model

Information model

Information modeling

Semantic Models

UML component diagram (enhanced in UML 2.0), SoaML

UML Class diagram
Parts of UML Metamodel

GeneralizableElement

Association

AssociationEnd

Classifier

+features

Feature

StructuralFeature

BehaviouralFeature

DataType

Class

Attribute

initialValue : Expression

isPolymorphic : Boolean

concurrency : CallConcurrencyKind

Operation

Specification

Telecom and Informatics
UML Information Modeling

- Ref also ISO 19103 Standard for Conceptual Modeling

- The following material is for reference …..
Objects

Can represents

- One instance
  - Ola : Person

- One type, interface
  - <<Interface>> Person

- One class
  - Person
### Person

<table>
<thead>
<tr>
<th>Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>navn : string</td>
</tr>
<tr>
<td>personnr. : integer</td>
</tr>
<tr>
<td>adresse : string</td>
</tr>
<tr>
<td>gasje : money</td>
</tr>
<tr>
<td>stillingstittel : string</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>endre-stilling()</td>
</tr>
<tr>
<td>endre-adresse()</td>
</tr>
</tbody>
</table>

**Example - object class**
User Story template

I <in the role of XX> needs functionality <zzz> to achieve the goal of <YYY>
Backlog metamodel

[Diagram showing the relationships between various components of a backlog metamodel, including Use Case, Backlog Item, Nonfunctional Requirement, Investment Theme, Epic, Feature, Story, Task, Business Epic, Architecture Epic, Feature Acceptance Test, User Story, Other Work Item, Story Acceptance Test, Unit Test, System Qualities Tests, and Constraints and Realizations.]
Use-Case Essentials

- A way to establish the requirements of the system
  - Use cases place requirements in context
- A way to establish the system boundary
  - The model identifies who or what interacts with the system and what the system should do
- A way to iteratively evolve the requirements
- A way to communicate the requirements to all the stakeholders
  - The use cases provide a common thread through all project activities
- A way to focus the development efforts on delivering customer value
- A way to verify that the requirements have been implemented

A way to effectively gather requirements and ensure that the system delivers real value to the customers and users
What is a Use Case?

A use case describes a sequence of actions a system performs that yields an observable result of value to a particular actor.

- Use cases are described in text.
- They tell the story of the interactions between actors and the system.

- Use cases are shown in UML diagrams.

```
Bank Customer ➔ Withdraw Cash
```
What do we need to produce?
What is ThingML?

ThingML is a modeling language for embedded and distributed systems. It is developed by the Networked Systems and Services department of SINTEF in Oslo, Norway.

ThingML stands for "Thing" Modeling Language as a reference to the so-called Internet of Things.

The idea of ThingML is to develop a practical model-driven software engineering toolchain which targets resource-constrained embedded systems such as low-power sensor and microcontroller-based devices.

ThingML is developed as a domain-specific modeling language which includes concepts to describe both software components and communication protocols. The formalism used is a combination of architecture models, state machines, and an imperative action language.

The ThingML toolset includes text editors to create and edit ThingML models, a set of transformations to create diagrams from ThingML models and a set of code generators to compile ThingML to C, Java and JavaScript.

http://thingml.org/
Supporting literature – EMF and GMF

- Dave Steinberg (Author), Frank Budinsky (Author), Marcelo Paternostro (Author), Ed Merks (Author)

- Book: Eclipse Modeling Project: A Domain-Specific Language (DSL) Toolkit (Paperback)
- Richard C. Gronback
Xtext

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MDSD

- Book: Model-Driven Software Development: Technology, Engineering, Management (Paperback) by Thomas Stahl, Markus Voelter, Krzysztof Czarnecki

- Engineering Service Oriented Systems: A Model Driven Approach, Karakostas, Bill; Zorgios, Yannis
DSL Engineering

- Markus Voelter
Next Lecture, January 22, 2018

Modeling structure and behaviour (UML and UML 2.0)

Class models as a basis for meta modeling