

# A Formal Framework for the Analysis of Human-Machine Interactions

*PhD Public Defence*

*Ir. Sébastien Combéfis (EPL/ICTM)*



# Automated interactive systems



**People are interacting with technology everyday!**

# Automated interactive systems



People are interacting with technology everyday!

# Automated interactive systems



People are interacting with technology everyday!

# Automated interactive systems



People are interacting with technology everyday!

# Automated interactive systems



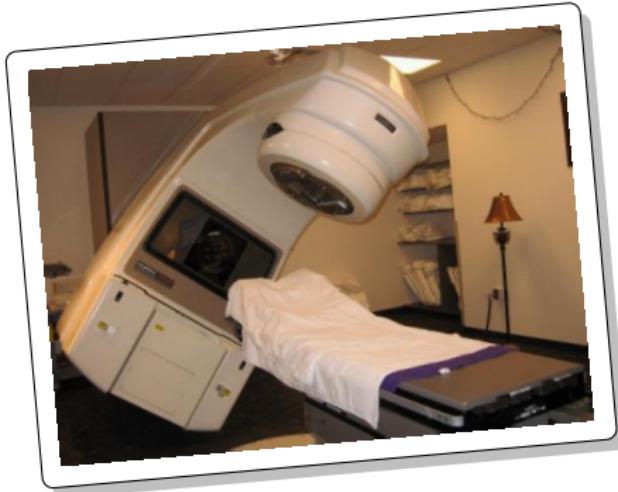
People are interacting with technology everyday!

# Automated interactive systems



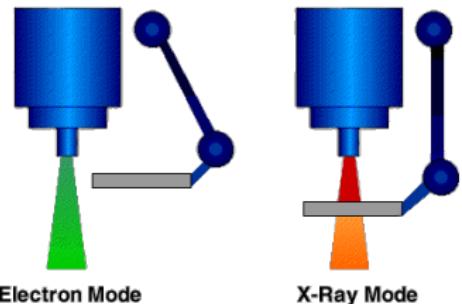
People are interacting with technology everyday!

# Automation surprise



## Therac-25

1985–1987

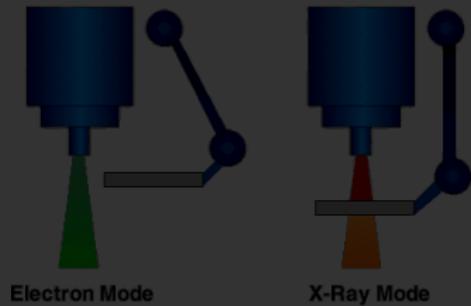


# Automation surprise



## Therac-25

1985–1987

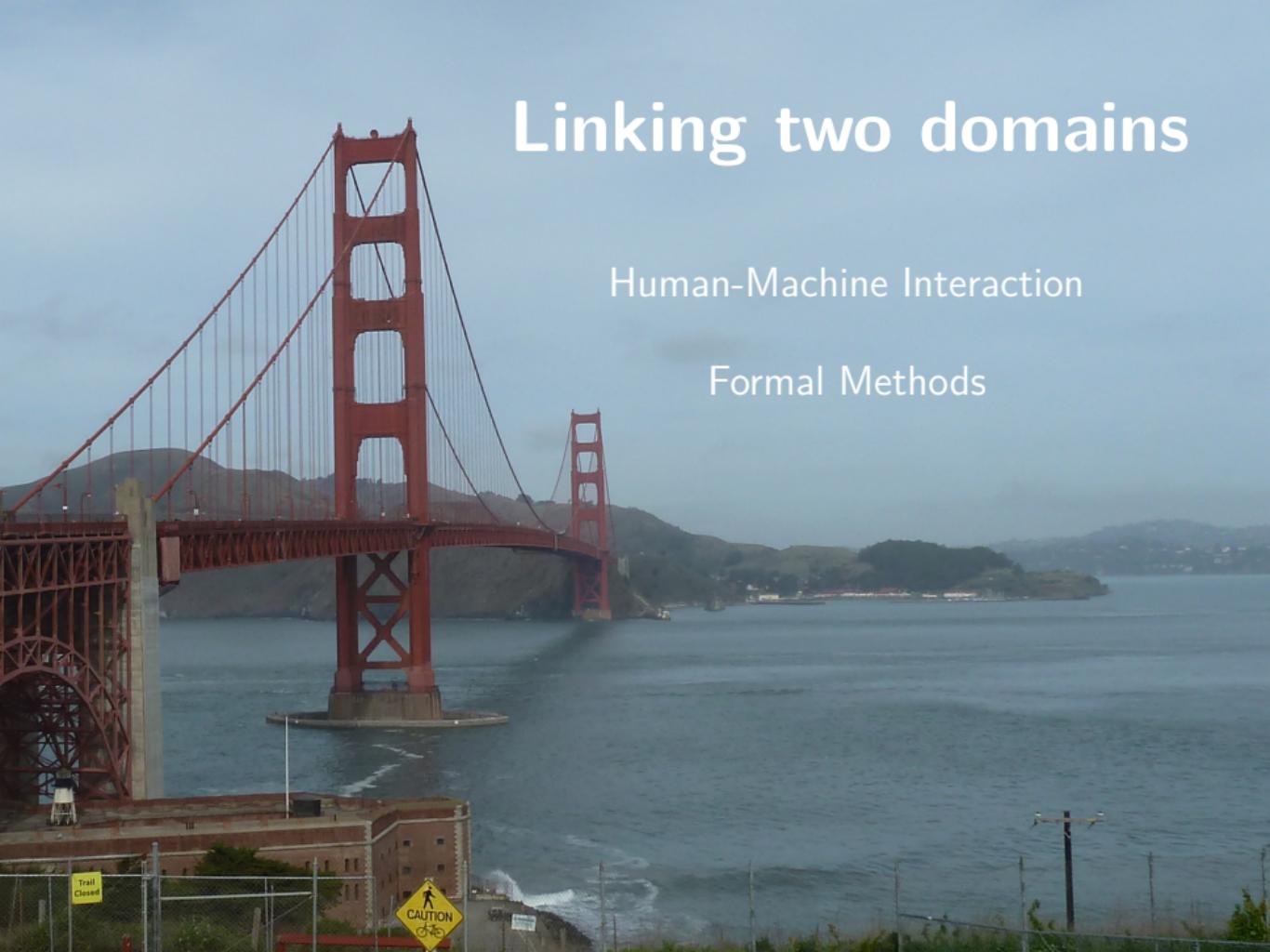


Did you said bug?



# Did you said bug?



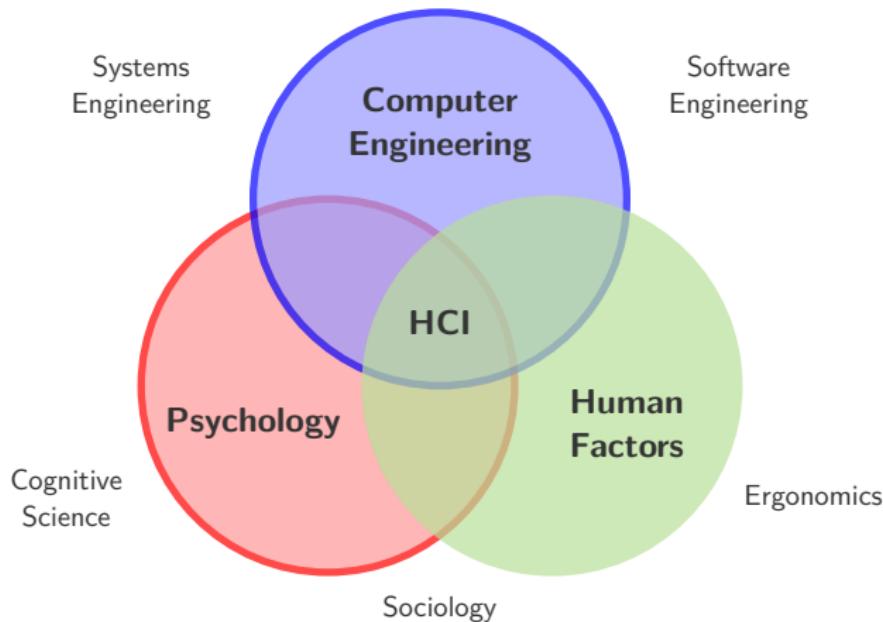


# Linking two domains

Human-Machine Interaction

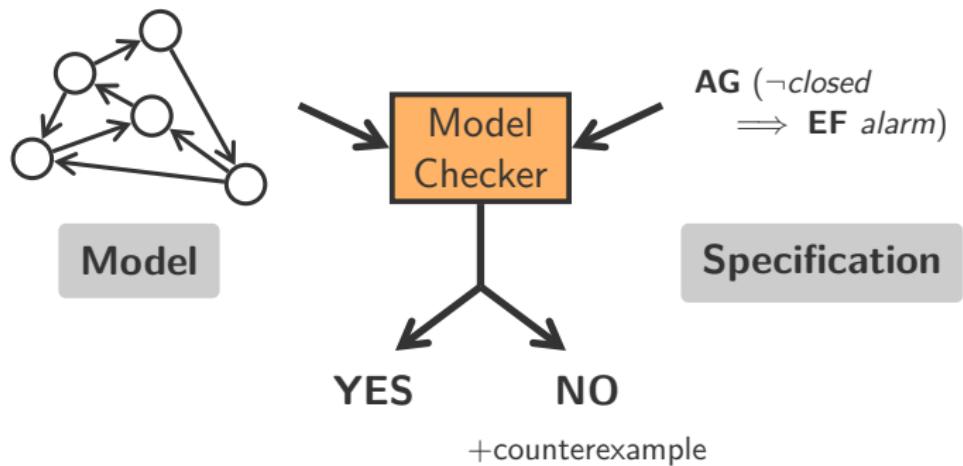
Formal Methods

# Human-computer interaction



Design, evaluation and implementation of  
interactive computing systems for human use

# Formal methods



Specification, development and verification of hardware and software systems using mathematical techniques

A metal sculpture of a figure, resembling a mouse or a small human, stands on a white-painted wooden balance beam. The figure is in a dynamic pose, leaning forward with one arm extended downwards and the other upwards. It wears large, round, dark sunglasses and has a small tuft of hair at the top of its head. The beam is positioned horizontally across the frame, extending from the left foreground towards the center. The background is a calm body of water with gentle ripples.

# Modelling the world around us

Simplification of the analyses

Validation of models

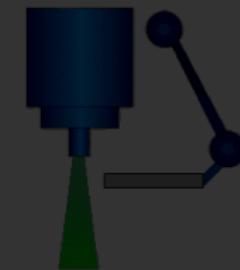
False positives and negatives

# Automation surprise

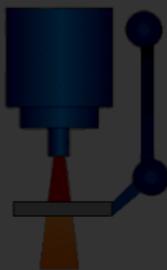


## Therac-25

1985–1987



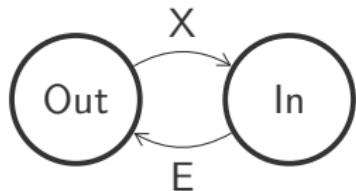
Electron Mode



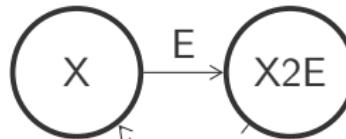
X-Ray Mode

# Automation surprise

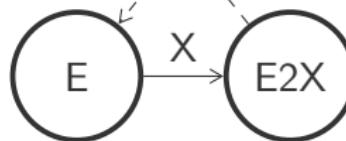
**Spreader**



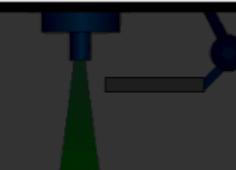
**BeamLevel**



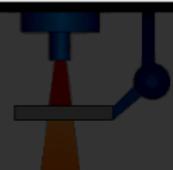
*X-ray mode*



*E-beam mode*



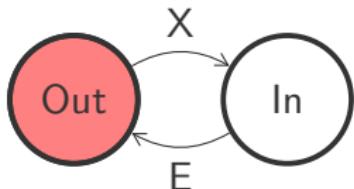
Electron Mode



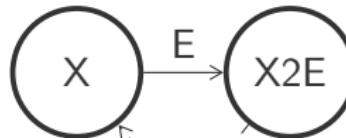
X-Ray Mode

# Automation surprise

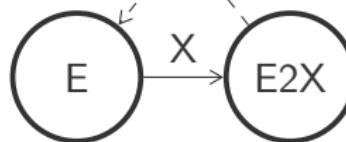
**Spreader**



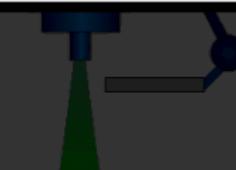
**BeamLevel**



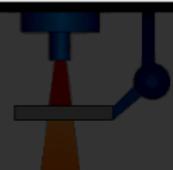
*X-ray mode*



*E-beam mode*

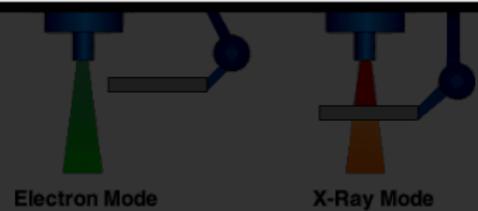
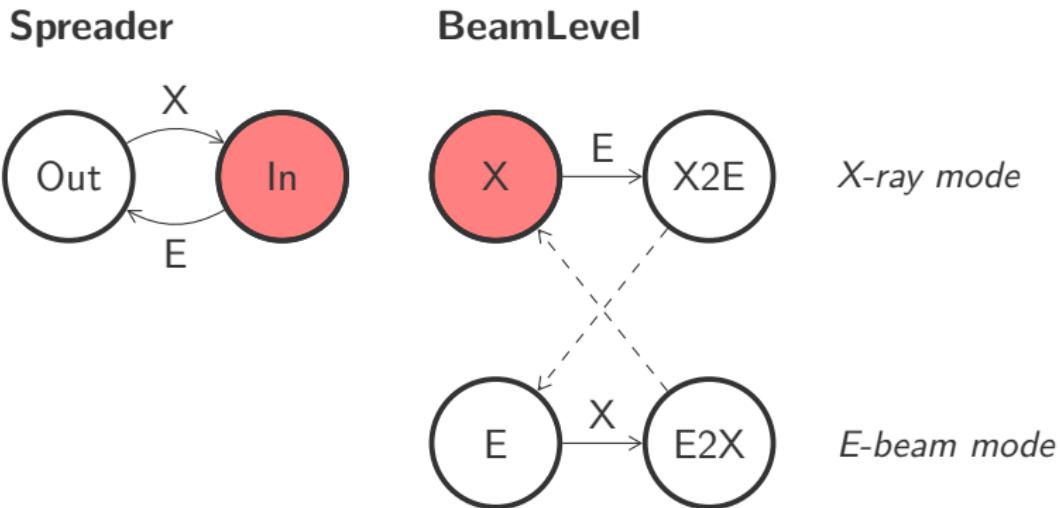


Electron Mode

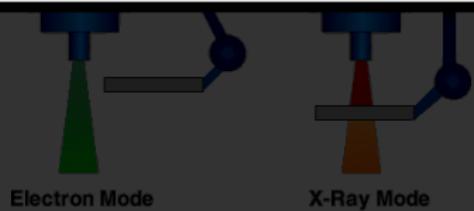
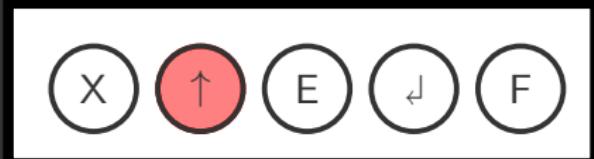
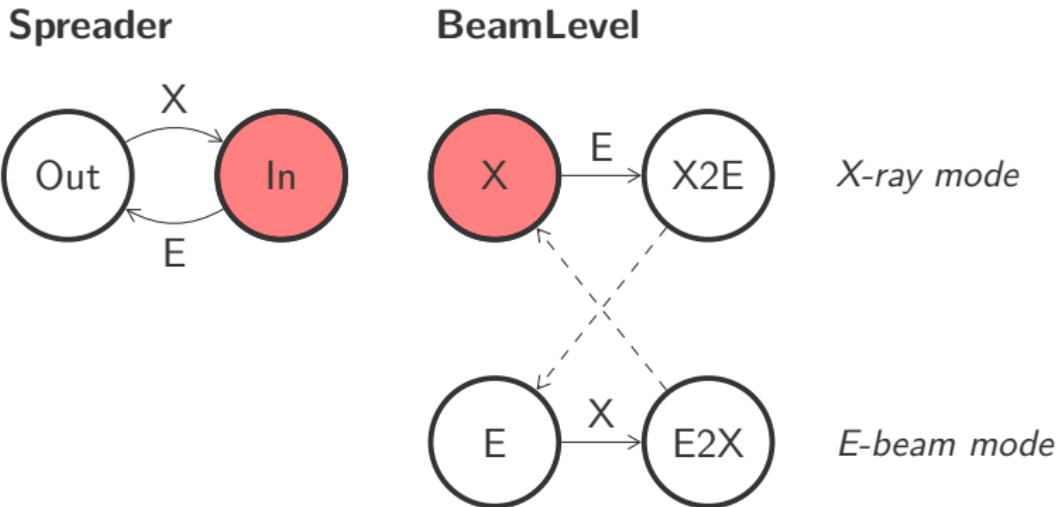


X-Ray Mode

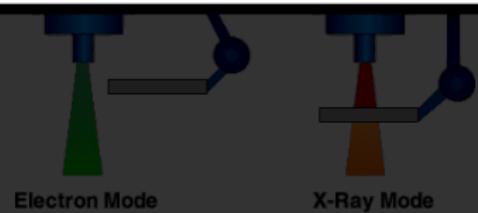
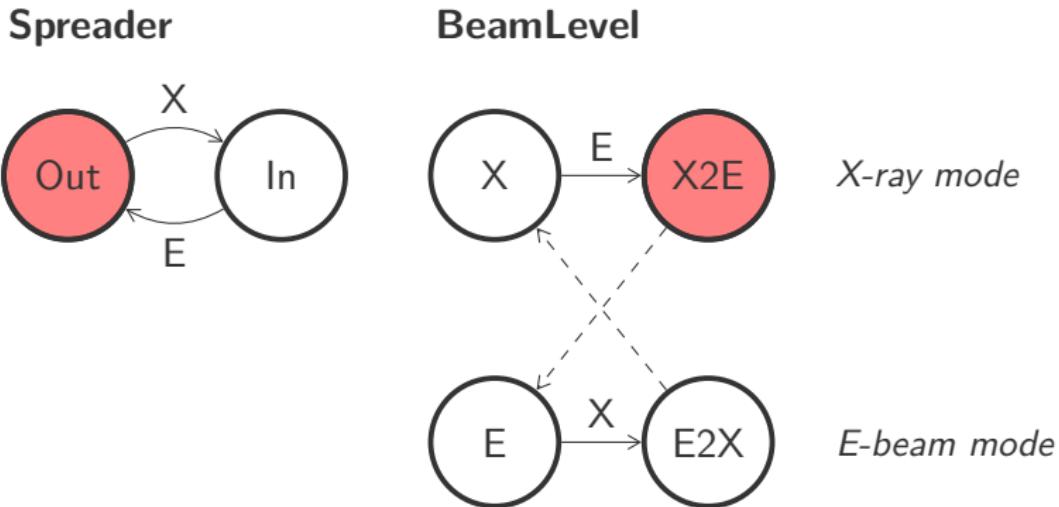
# Automation surprise



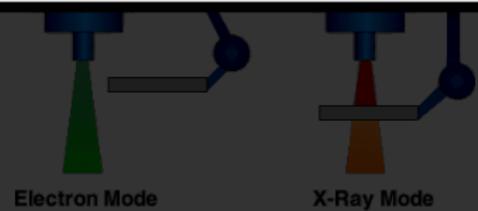
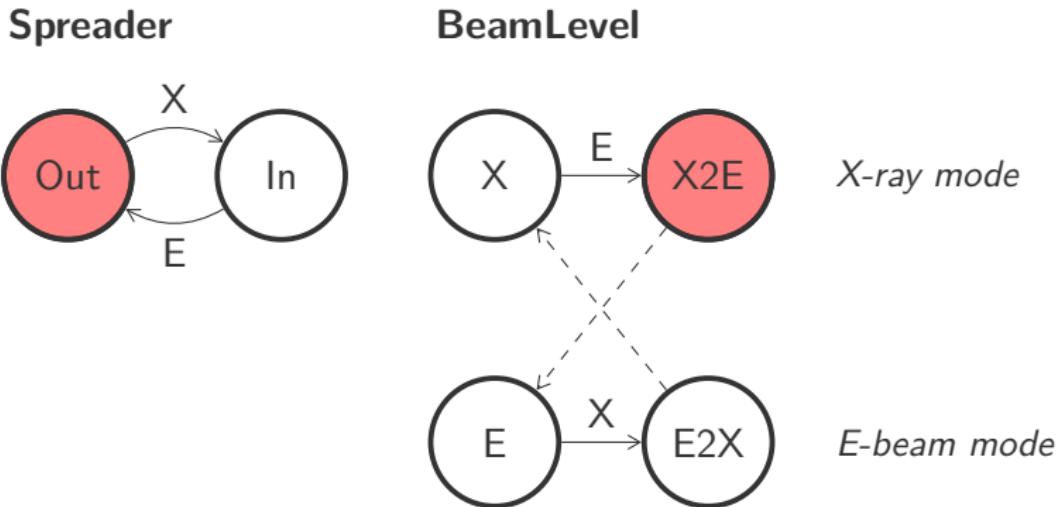
# Automation surprise



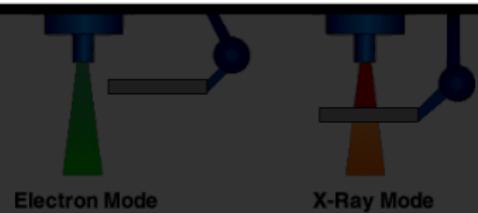
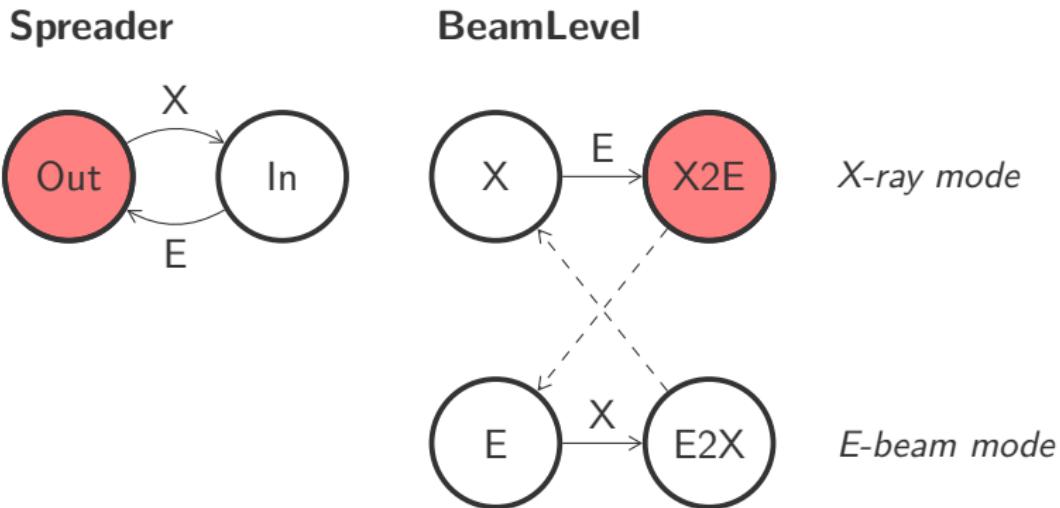
# Automation surprise



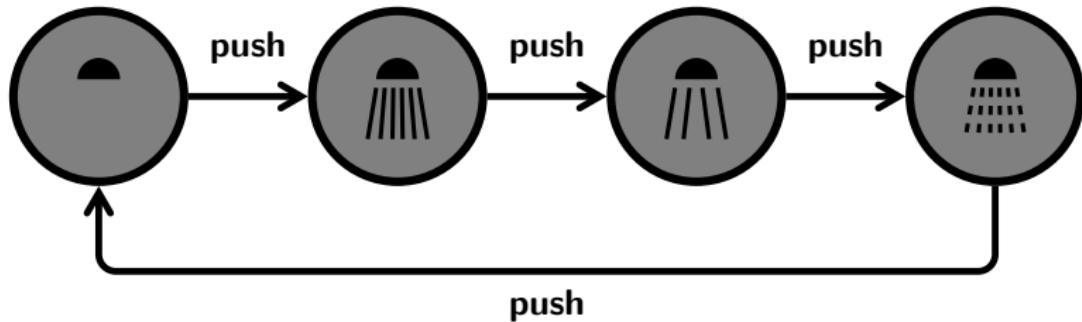
# Automation surprise



# Automation surprise

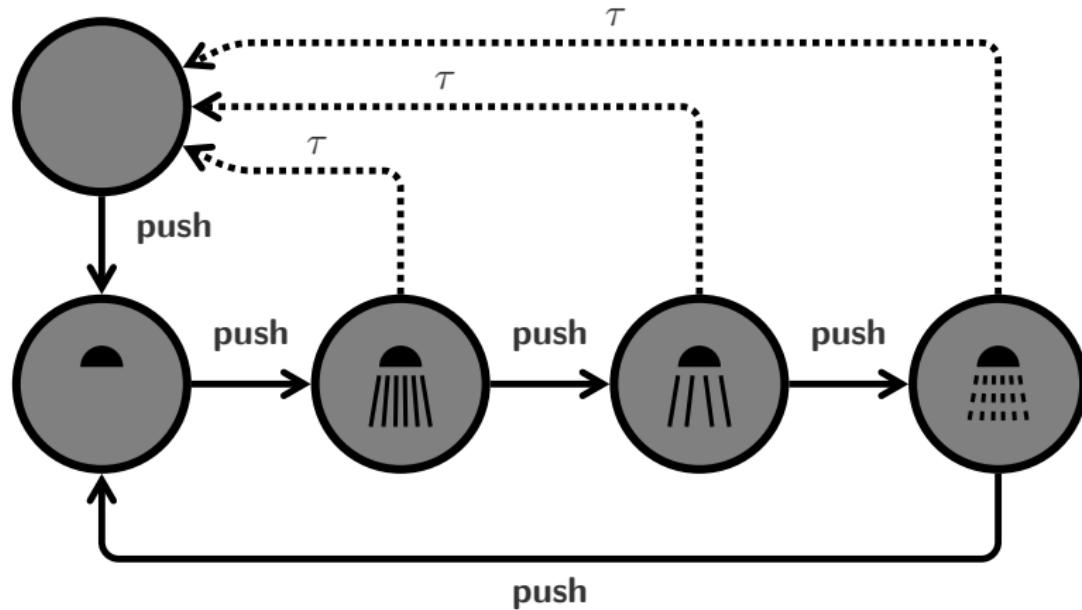


## Model of the system



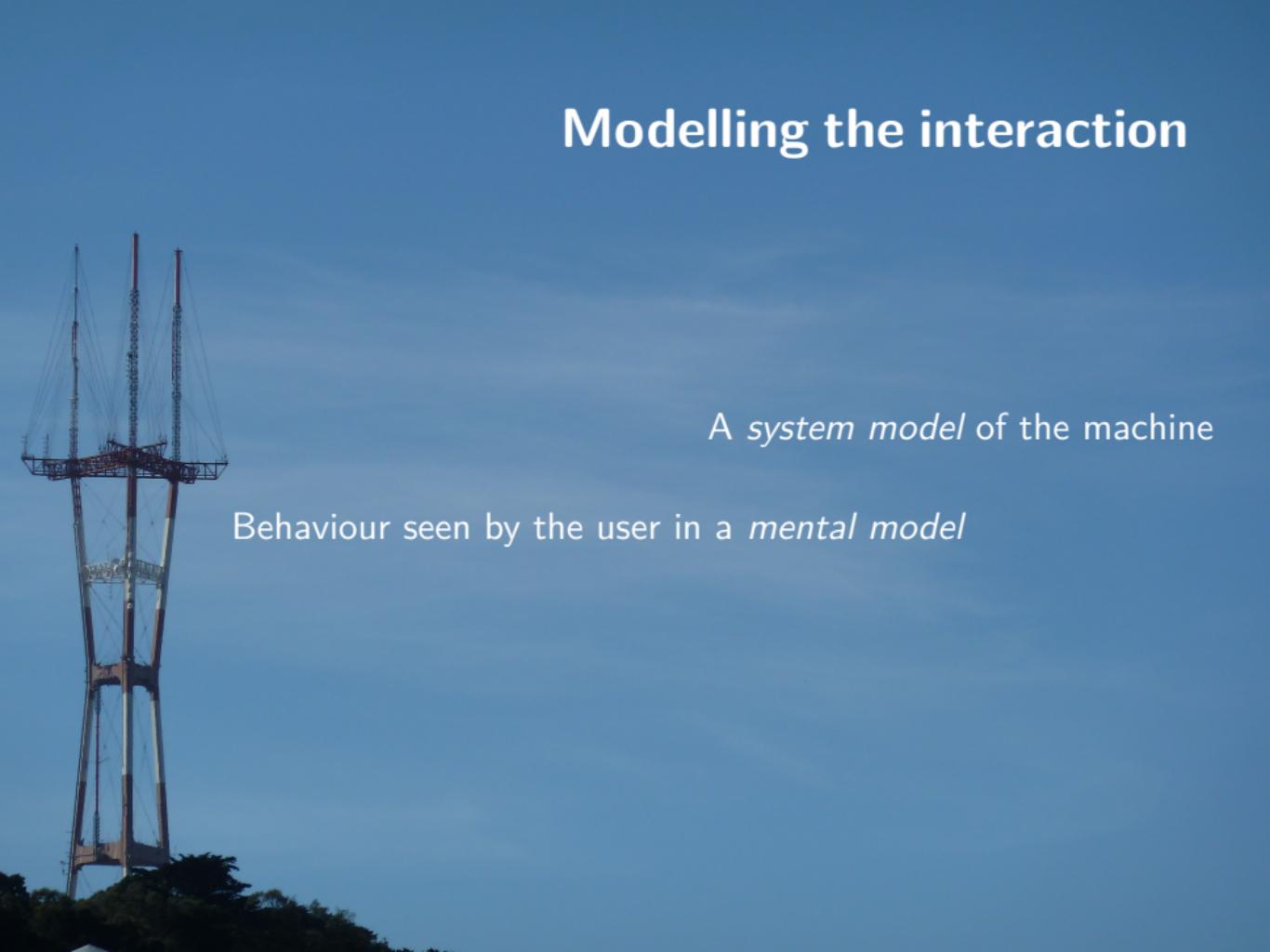
That model do NOT reflect the actual behaviour of the system!

## Actual model of the system



Internal changes are occurring autonomously in the system!

# Modelling the interaction



Behaviour seen by the user in a *mental model*

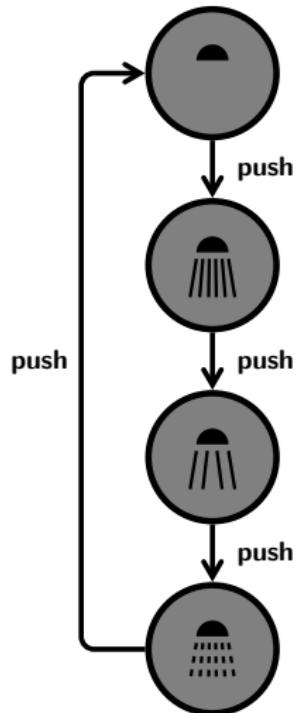
A *system model* of the machine

# Modelling the interaction

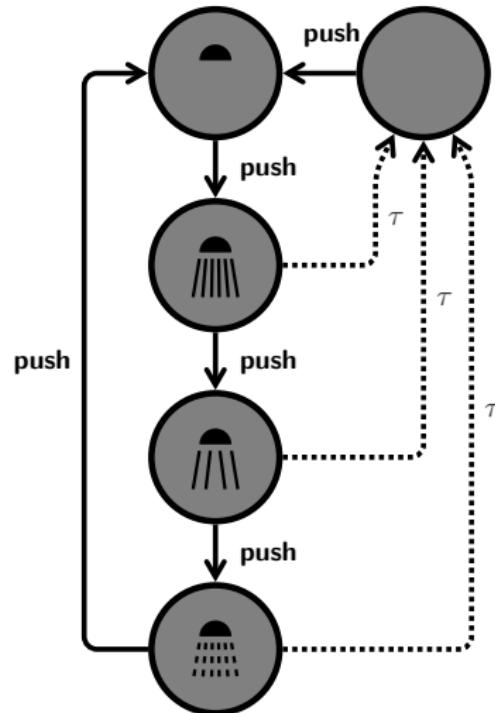


A *system model* of the machine  
+  
Behaviour seen by the user in a *mental model*  
↓  
*interaction model*

# Interaction model

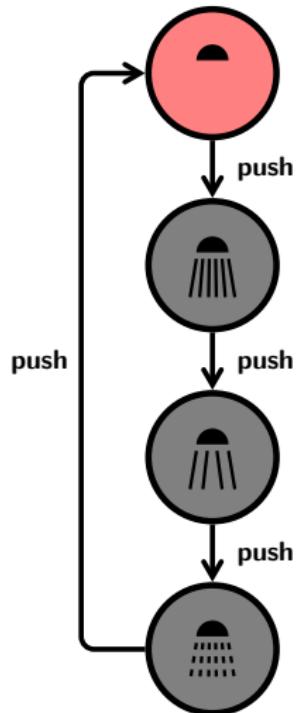


Mental model

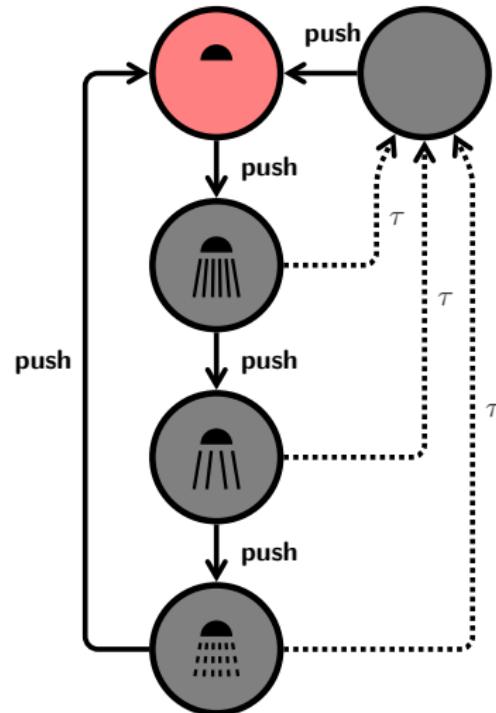


System model

# Interaction model

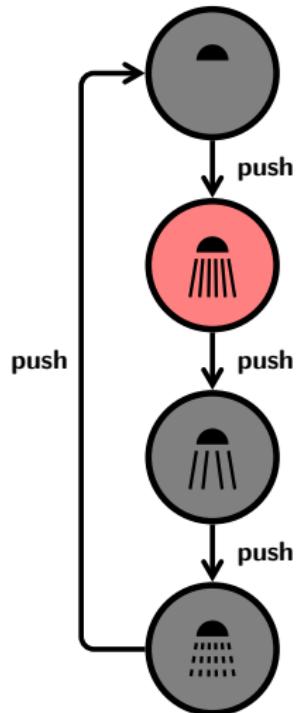


Mental model

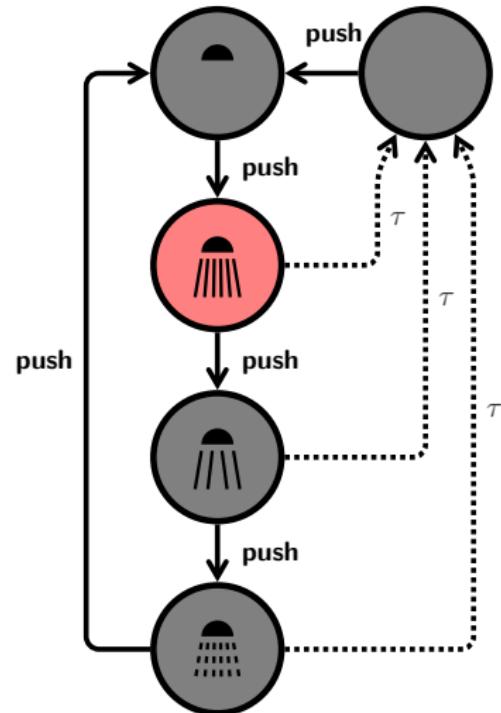


System model

# Interaction model

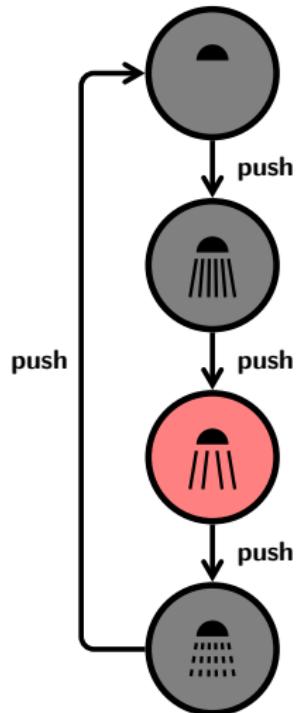


Mental model

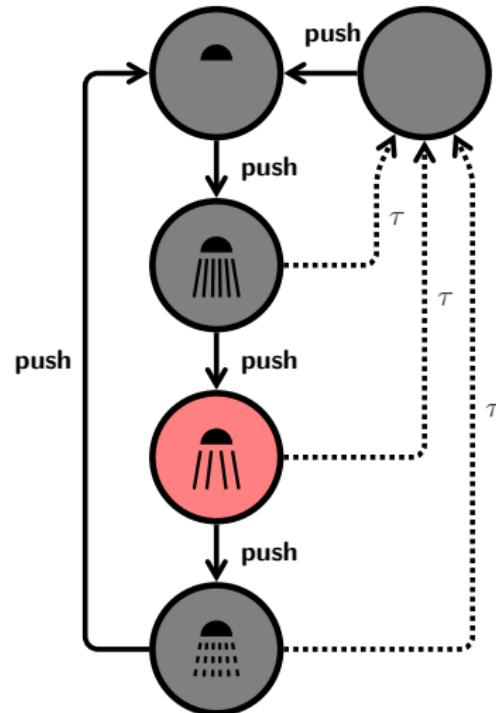


System model

# Interaction model

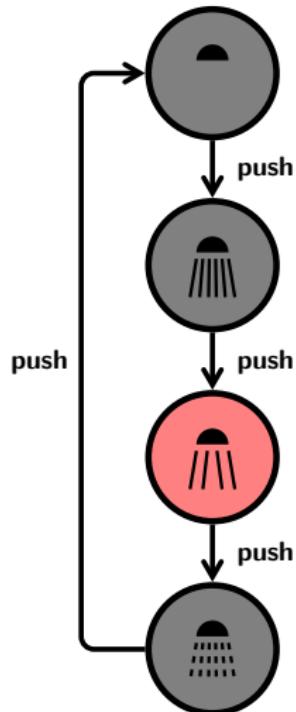


Mental model

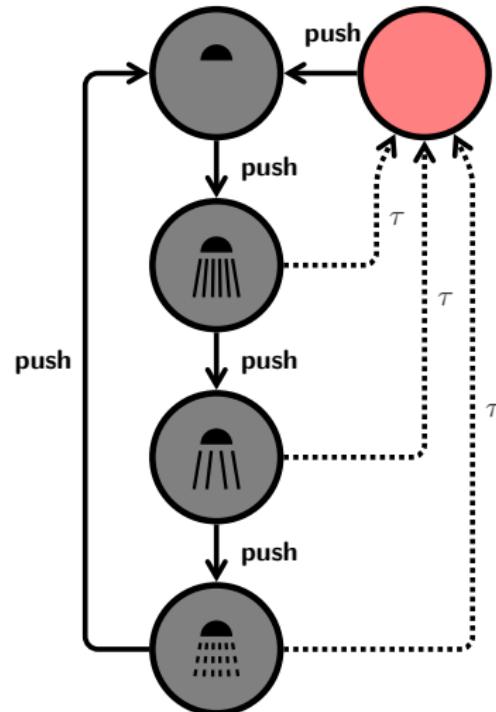


System model

# Interaction model

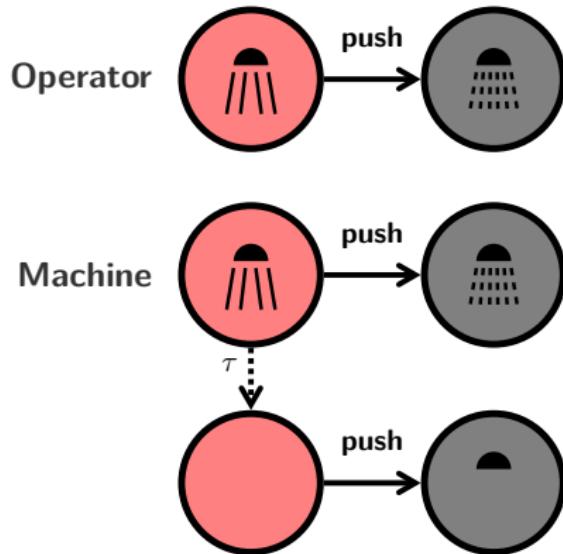


Mental model

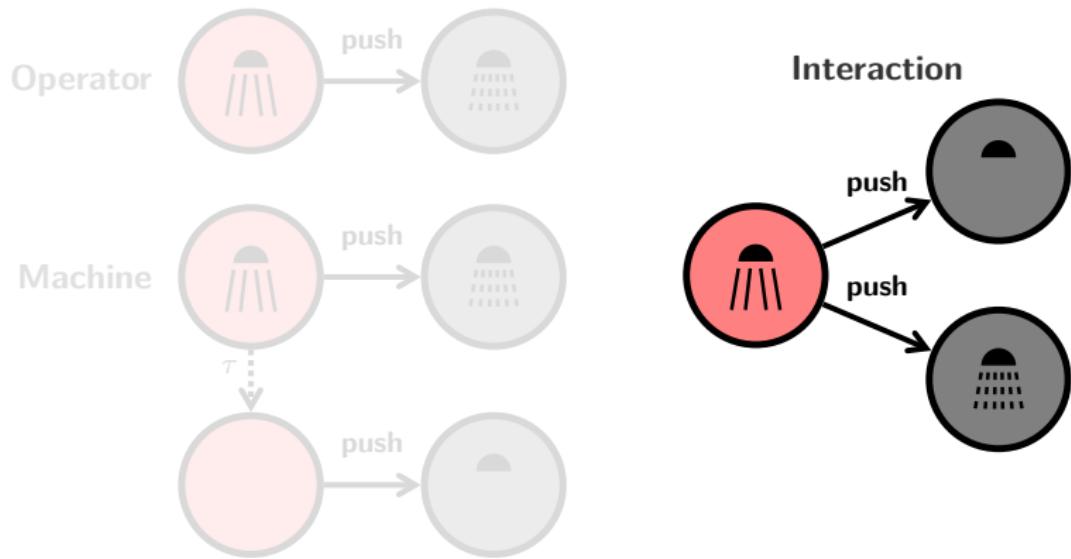


System model

# Mode confusion



# Mode confusion



The operator does NOT understand the machine anymore!

# This thesis

Choosing models for systems and humans

Defining and characterising full-control

Implementing generation algorithms

Evaluating the approach on case studies

