Petri-net Based Animation with CPN Tools and BRITNeY animation

Michael Westergaard

mw@daimi.au.dk

Department of Computer Science
University of Aarhus

Motivation

- High-level graphics makes it easier to demonstrate and communicate models

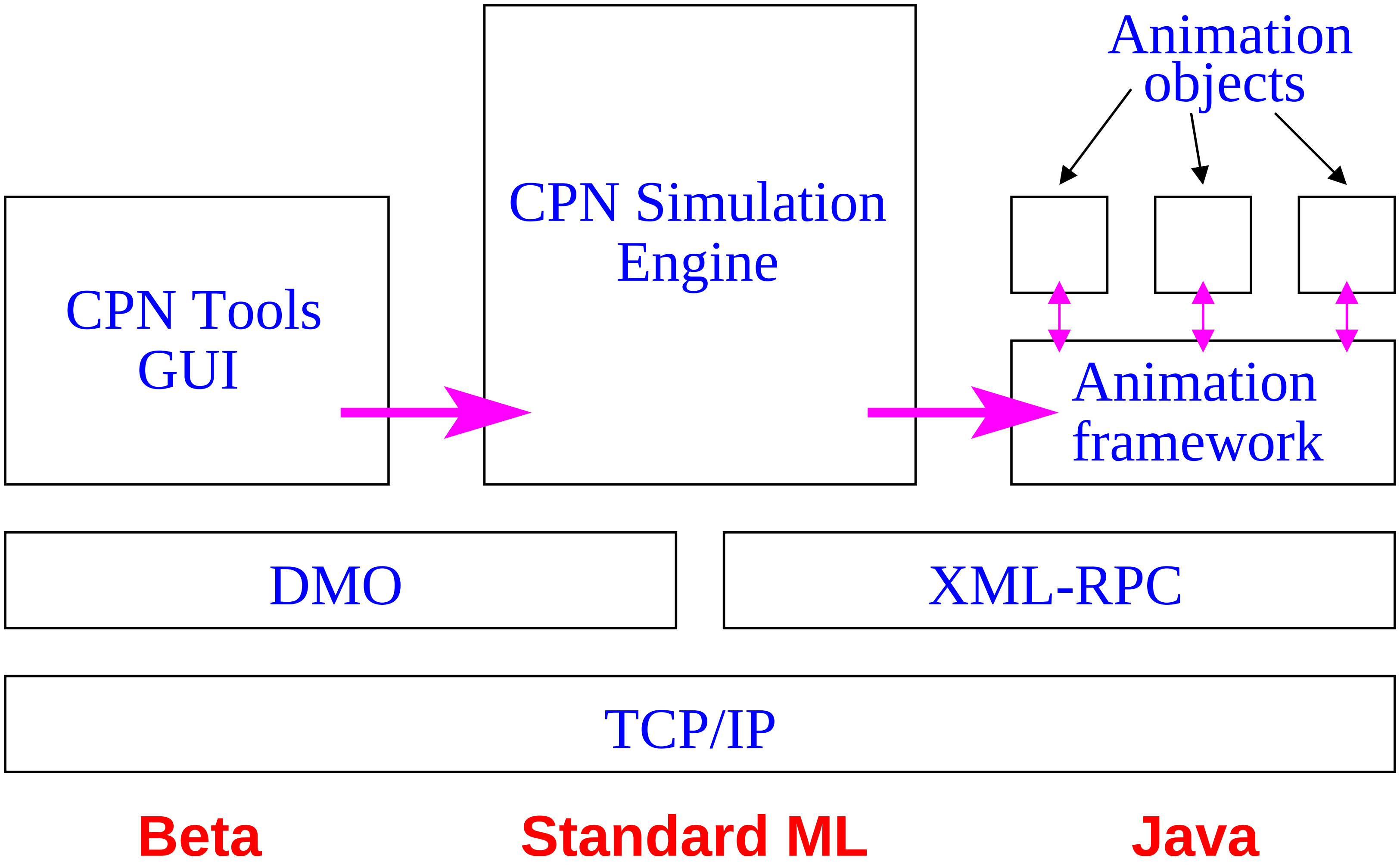
Overview

- Architecture
- Hello World
- Dining Philosophers
- Stop Signal
- A closer look at ShowModal
- Future work & conclusion

Overview

- Architecture $\Leftarrow$
- Hello World
- Dining Philosophers
- Stop Signal
- A closer look at ShowModal
- Future work & conclusion

Overall Architecture



Why Java?

- Well-known by many computer scientists
- Well-suited for creating graphics
- A huge number of libraries already exist $\Longrightarrow$ it is easy to create even very complex animation objects

Overview

- Architecture
- Hello World $\Leftarrow$
- Dining Philosophers
- Stop Signal
- A closer look at ShowModal
- Future work & conclusion

Hello World (1/3)

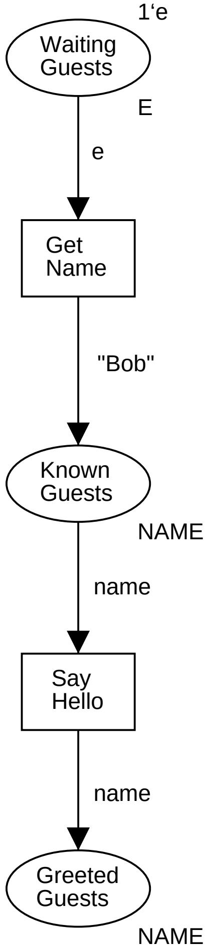
The purpose of this example is

- to introduce connections
- to see the `ShowModal` and `GetString` animation objects
- to see how the animation functions can be used

Hello World (2/3)

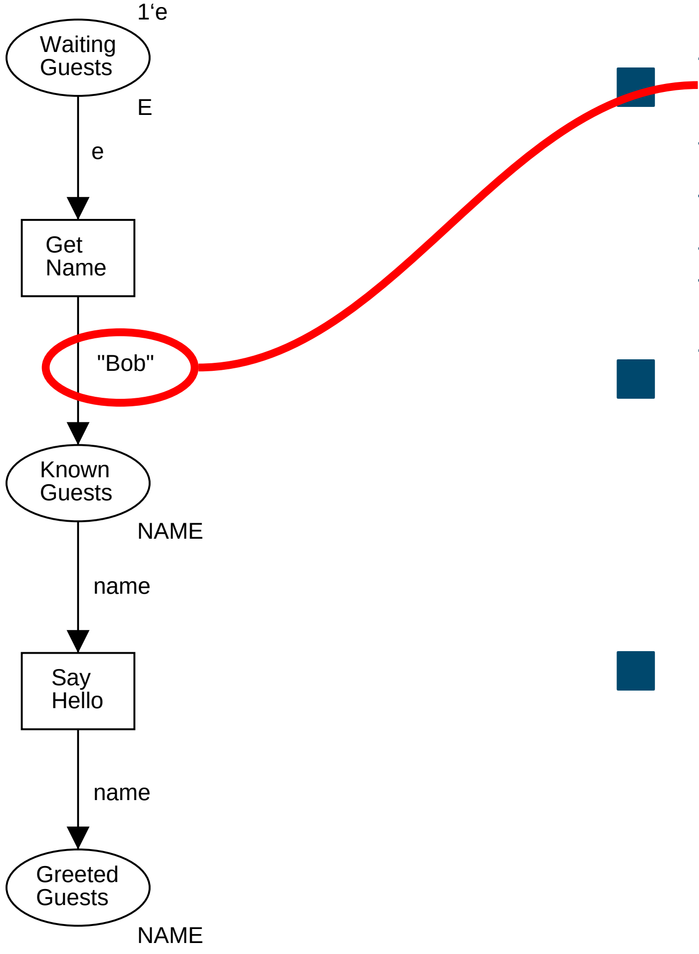
- We want to model part of a hotel
- We focus on the clerk at the counter
- When a guest enters the clerk asks for his name
- The clerk then greets the guest

Hello World (3/3)



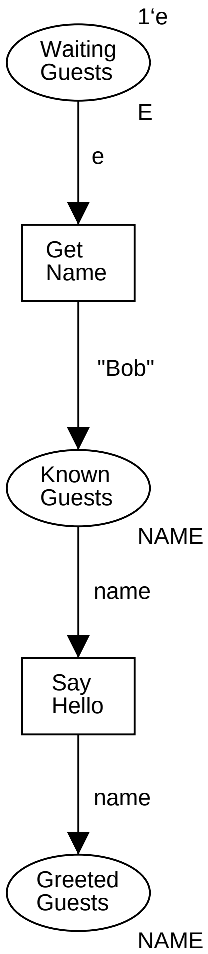
- We notice that we have hard-coded the name of the guest
- We would rather allow the user to act as the guest
- . . . for this we will use some simple standard functions

Hello World (3/3)



- We notice that we have hard-coded the name of the guest
- We would rather allow the user to act as the guest
- …for this we will use some simple standard functions

Hello World (3/3)



- We notice that we have hard-coded the name of the guest
- We would rather allow the user to act as the guest
- …for this we will use some simple standard functions

Setting up a Connection (1/2)

- In order to use the animation package, we must first set up a connection to an animation object
- In this example, we will add the declaration

```
structure msg =
  ShowModalInstance(
      val name = "Message");
```

- This can be thought of as creating a proxy object, `msg`, with an interface, `ShowModal`, in e.g. Java

Setting up a Connection (2/2)

- The interface of `ShowModal` is:

```
sig
  val displayMessage: string -> int
end
```

- That is, we can call

```
msg.displayMessage("Hello World")
```

to show the message “Hello World” to the user

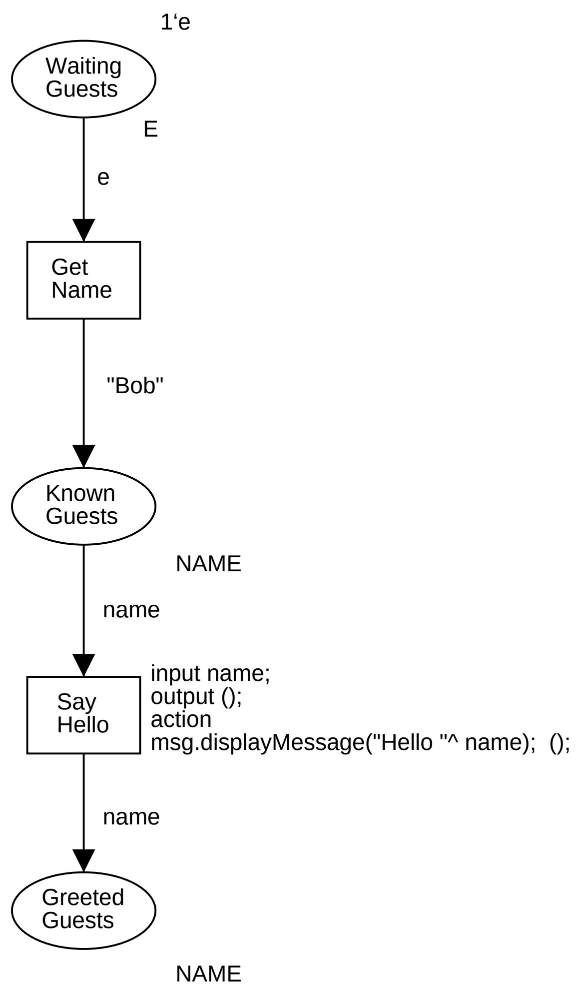
Using Animation Functions (1/2)

- CPN Tools allows code-fragments to be executed whenever a transition occurs
- Code-fragments have the syntax:

```
input (...)
output (...)
action
...
```

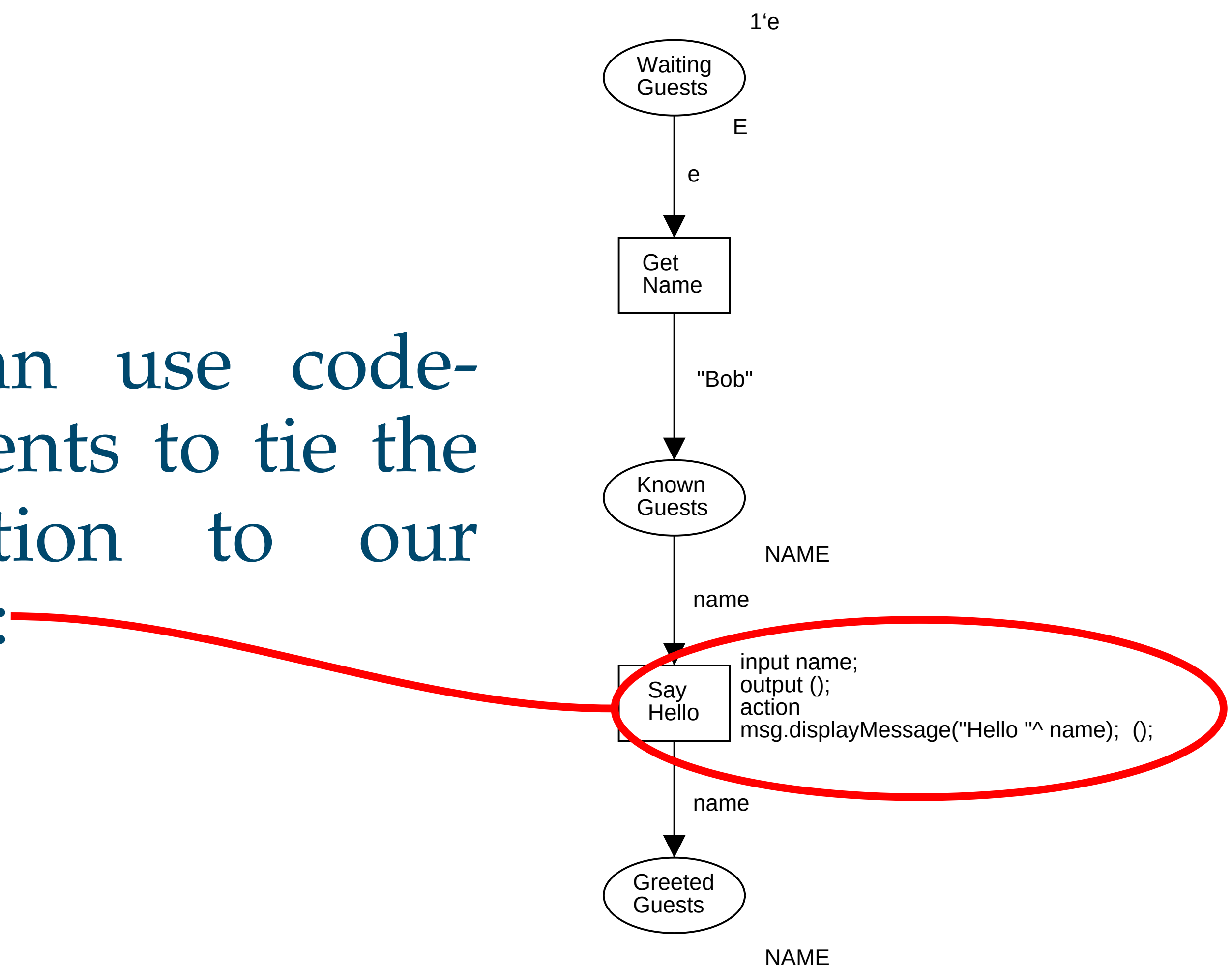
Using Animation Functions (2/2)

- We can use code-fragments to tie the animation to our model:



Using Animation Functions (2/2)

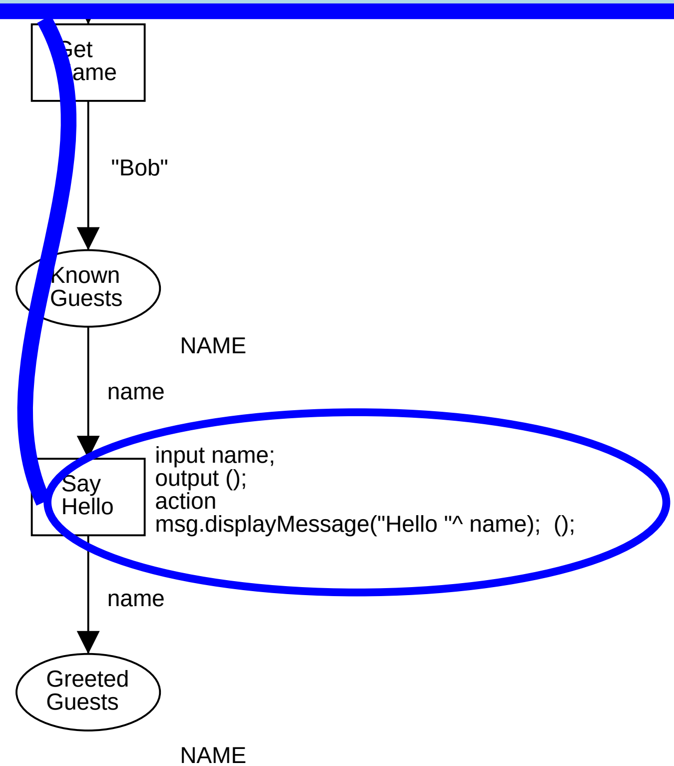
- We can use code-fragments to tie the animation to our model:



Using Animation Functions (2/2)

```
input name;
output ();
action
msg.displayMessage("Hello " ^ name); ();
```

- We can use code-fragments to tie the animation to our model:



Asking for a Guest’s Name (1/2)

- We create a connection

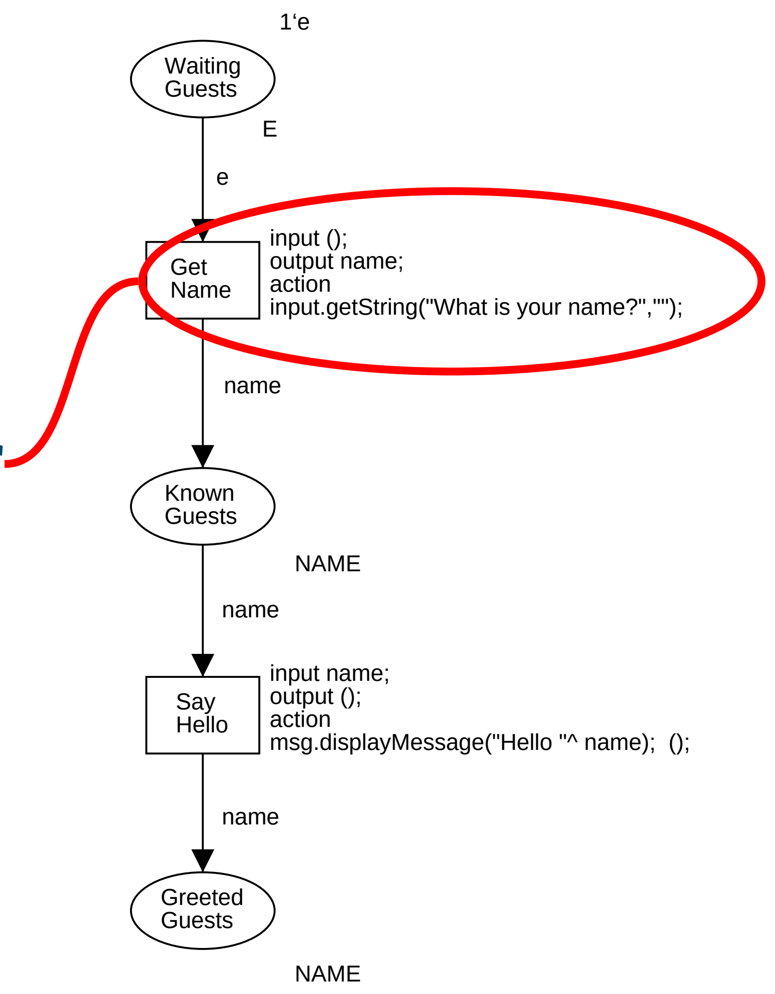
```
structure input =
  GetStringInstance(
      val name = "Question");
```

with the interface:

```
sig
  val getString:
        string * string -> string
end
```

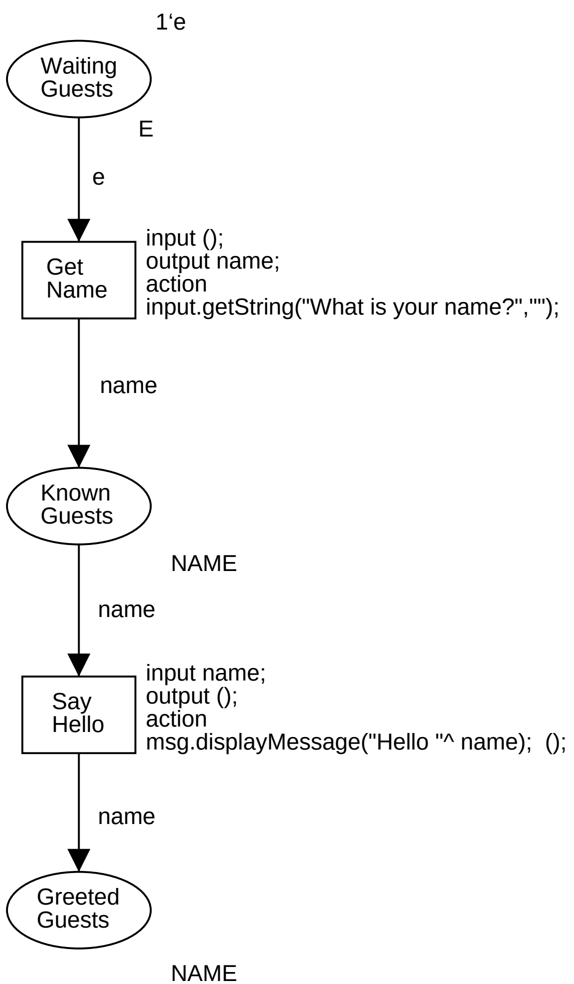
Asking for a Guest’s Name (2/2)

- …and use it in our model



Asking for a Guest's Name (2/2)

- . . . and use it in our model



So Far, We Have Seen. . . (1/3)

. . . how to create connections to an animation object:

```
structure msg =
  ShowModalInstance(
      val name = "Message");
```

So Far, We Have Seen. . . (2/3)

. . . 2 animation object interfaces:

- ShowModal:

```
sig
  val displayMessage: string -> int
end
```

- GetString:

```
sig
  val getString:
        string * string -> string
end
```

So Far, We Have Seen. . . (3/3)

. . . how to use connections in our nets using code-fragments:

```
input name;
output ();
action
msg.displayMessage("Hello " ^ name); ();
```

Overview

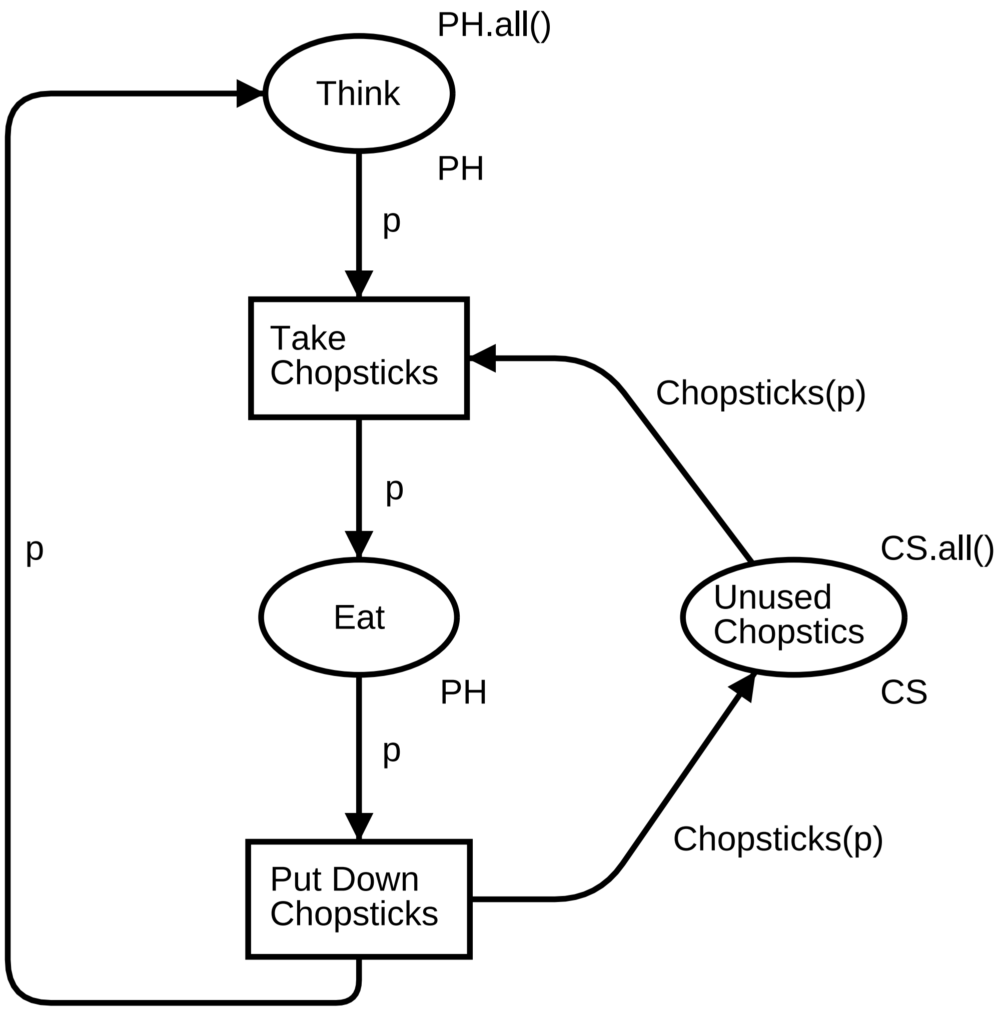
- Architecture
- Hello World
- Dining Philosophers $\Leftarrow$
- Stop Signal
- A closer look at ShowModal
- Future work & conclusion

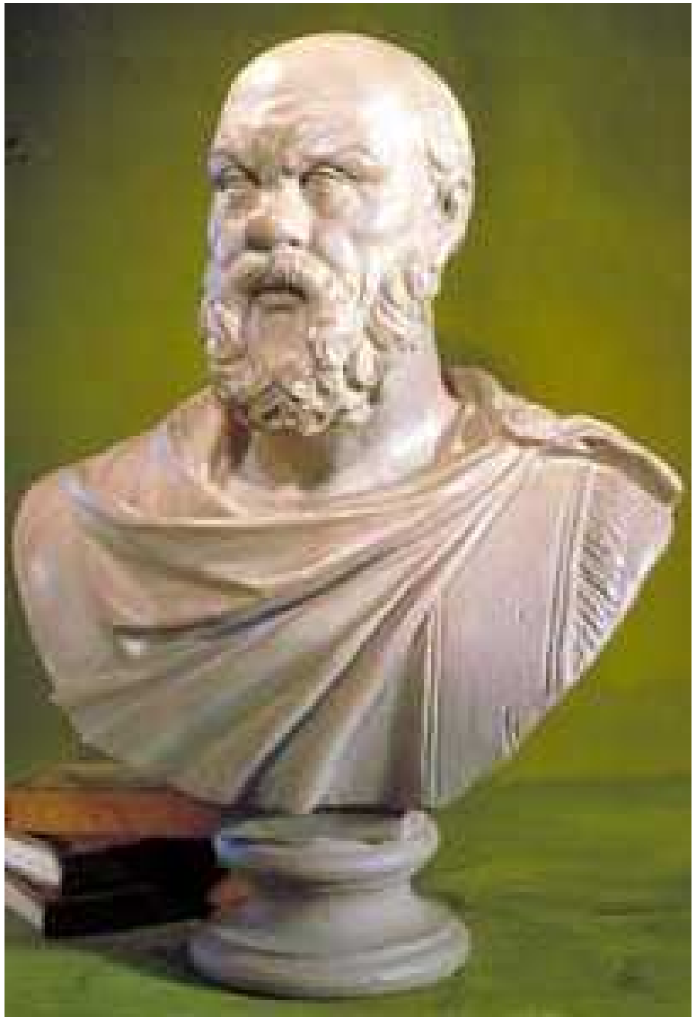
Dining Philosophers (1/2)

The purpose of this example is

- to see the `GraphSheet` animation object
- to see how we can write small libraries using the animation functions

Dining Philosophers (2/2)





GraphSheet

- We want to generate and draw the state-space
- For this, we will use `GraphSheet`:

```
sig
  val createVertex: string -> int
  val createEdge:
        string * string * string
          -> int

  val doLayout: unit -> int
  val export: unit -> int
end
```

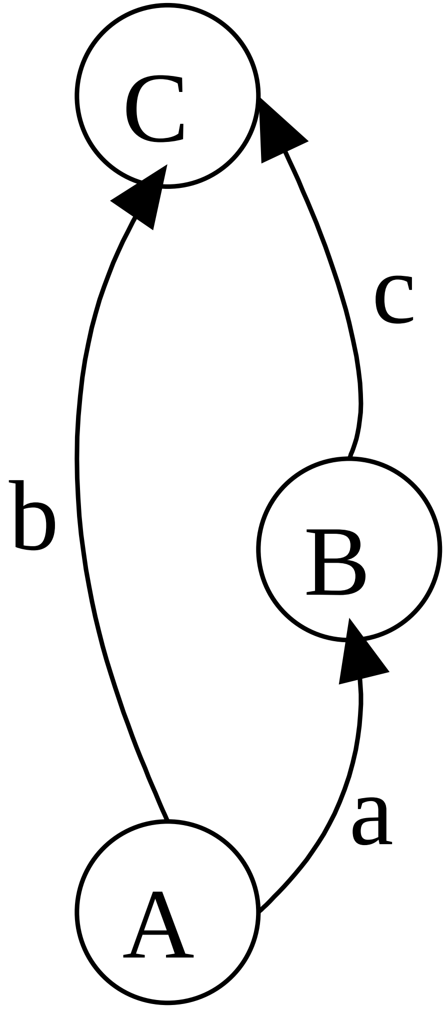
State-space Functions (1/2)

- The CPN Tools state-space tool provides a number of functions:

```
val EvalAllNodes:
      (Node -> 'a) -> 'a list
val EvalAllArcs:
      (Arc -> 'a) -> 'a list
val SourceNode: Arc -> Node
val DestNode: Arc -> Node
val st_Node: Node -> string
```

State-space Functions (2/2)

- `SourceNode(a) = A`
- `DestNode(a) = B`
- `st_Node(A) = "A"`
- `EvalAllNodes(fn x => x)`
  `= [A, B, C]`
- `EvalAllArcs(fn x => x)`
  `= [a, b, c]`



Drawing all Nodes

We assume a connection to a `GraphSheet` animation object named `graph`

- Draw one node, A:
  `graph.createVertex(st_Node(A))`

Drawing all Nodes

We assume a connection to a `GraphSheet` animation object named `graph`

- Draw one node, A:
  `graph.createVertex(st_Node(A))`
- Draw an arbitrary node:
  ```
  fun drawNode n =
    graph.createVertex(st_Node(n))
  ```

Drawing all Nodes

We assume a connection to a `GraphSheet` animation object named `graph`

- Draw one node, A:
  `graph.createVertex(st_Node(A))`
- Draw an arbitrary node:
  ```
  fun drawNode n =
    graph.createVertex(st_Node(n))
  ```
- Draw all nodes:
  `EvalAllNodes(drawNode)`

Drawing all Arcs

- Draw one arc, a, from A to B:

```
graph.createEdge(
        st_Node(A), st_Node(B), "")
```

Drawing all Arcs

- Draw one arc, a, from A to B:
```
graph.createEdge(
     st_Node(A), st_Node(B), "")
```
- Draw one arc, a:
```
graph.createEdge(
     st_Node(SourceNode(a)),
     st_Node(DestNode(a)), "")
```

Drawing all Arcs

- Draw one arc, a:

```
graph.createEdge(
      st_Node(SourceNode(a)),
      st_Node(DestNode(a)), "")
```

- Draw an arbitrary arc:

```
fun drawArc a =
  graph.createEdge(
        st_Node(SourceNode(a)),
        st_Node(DestNode(a)), "")
```

Drawing all Arcs

- Draw one arc, a:

```
graph.createEdge(
        st_Node(SourceNode(a)),
        st_Node(DestNode(a)), "")
```

- Draw an arbitrary arc:

```
fun drawArc a =
    graph.createEdge(
            st_Node(SourceNode(a)),
            st_Node(DestNode(a)), "")
```

- Draw all arcs:

```
EvalAllArcs(drawArc)
```

All Drawing-code (1/3)

```
fun drawNode n =
  graph.createVertex(st_Node(n))

EvalAllNodes(drawNode)

fun drawArc a =
  graph.createEdge(
      st_Node(SourceNode(a)),
      st_Node(DestNode(a)), "")

EvalAllArcs(drawArc)
```

All Drawing-code (2/3)

- The code does not depend on the net at all
- We may want to draw state-spaces for other nets as well
- $\Longrightarrow$ creating a small library seems like a good idea
- We will then be able to draw a state-space by issuing:
  `use("visualise.sml")`

All Drawing-code (3/3)

- A slightly more elaborate library has been implemented
  - Support for drawing only parts of a state-space
  - Support for better names of nodes and arcs
- Using this library, drawing a state-space is as simple as:

```
use("visualise.sml");
NiceLabels();
DrawEntireGraph();
```

So Far, We Have Seen. . . (1/2)

. . . the GraphSheet animation object interface:

```
sig
  val createVertex: string -> int
  val createEdge:
        string * string * string
          -> int

  val doLayout: unit -> int
  val export: unit -> int
end
```

So Far, We Have Seen. . . (2/2)

. . . how to

- use GraphSheet with the state-space functions
- create a small library for drawing state-spaces, which can be used as:

```
use("visualise.sml");
NiceLabels();
DrawEntireGraph();
```

Overview

- Architecture
- Hello World
- Dining Philosophers
- Stop Signal $\Leftarrow$
- A closer look at ShowModal
- Future work & conclusion

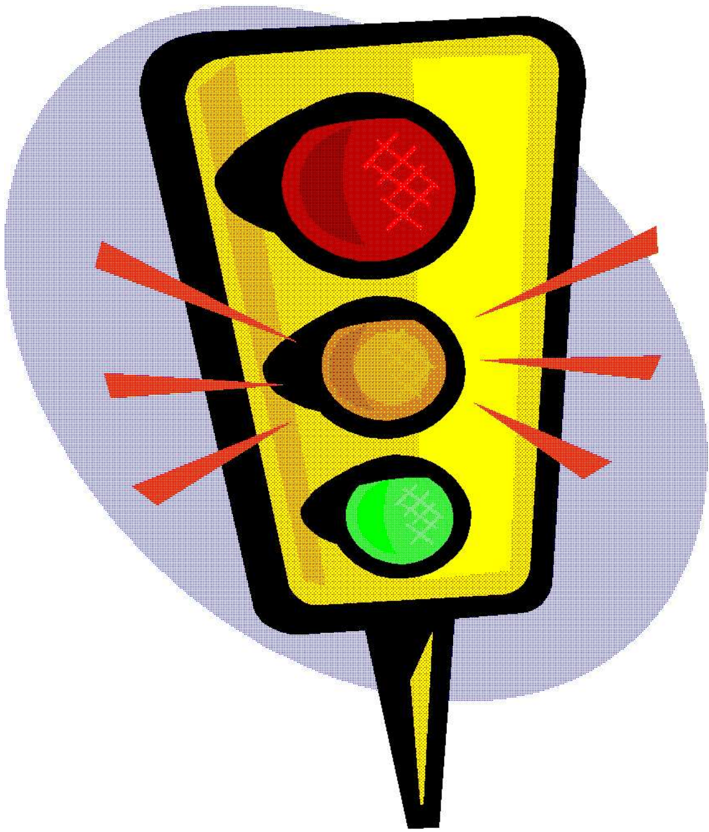
Stop Signal (1/3)

The purpose of this example is

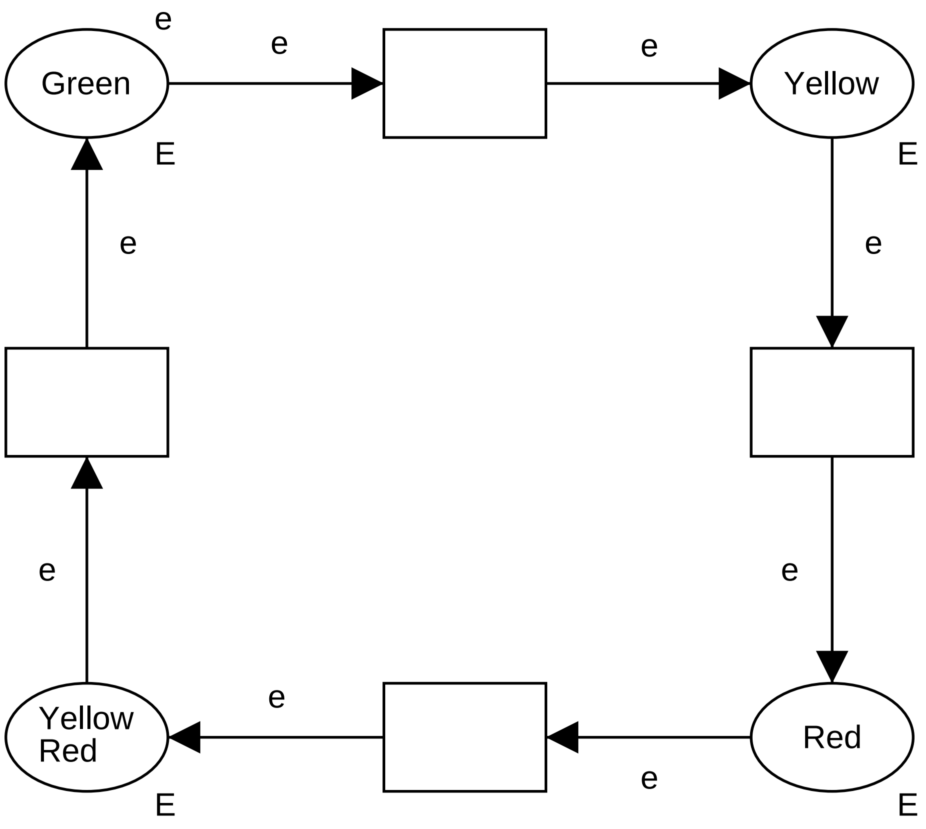
- to introduce the SceneBeans animation object
  - Creating animation-description files
  - Loading animation-description files
  - Invoking commands in the animation
  - Setting parameters in the animation
  - Listening for events from the animation

Stop Signal (2/3)

- A danish stop signal cycles between the colours:
  - green
  - yellow
  - red
  - yellow + red
- We want to model this



Stop Signal (3/3)



- We would like to visualise this...

SceneBeans (1/3)

- From the SceneBeans homepage[a]: *"SceneBeans is a Java framework for building and controlling animated graphics… It is used in the LTSA tool to animate formal models of concurrent systems"*
- SceneBeans was designed and implemented by Nat Pryce of Imperial College, London

[a] `http://www-dse.doc.ic.ac.uk/Software/SceneBeans/`

SceneBeans (2/3)

- A SceneBeans animation is described using XML
- Once an animation is started, it communicates with the surroundings using
  - commands
  - events
- SceneBeans is written in Java… why not try to use it?

SceneBeans (3/3)

The interface of `SceneBeans` is:

```
sig
  val setAnimation: string -> int

  val getNextEvent: unit -> string
  val peekNextEvent: unit -> string
  val waitForEvent: string -> int
  val hasMoreEvents: unit -> bool

  val setValue:
      string * string * string -> int
  val invokeCommand: string -> int
end
```

Definition of an XML File

- We create an XML file describing the animation of our model
- Assuming we have a connection to a SceneBeans animation object named `lights`, we can load our XML file using:

```
lights.setAnimation("stop.xml");
```

Clearing all High-lights

- In the XML file file, a `clear` command is defined
- The clear command can be invoked by:

```
lights.invokeCommand("clear");
```

High-lighting a Circle

- As the red, yellow, and green circles have an ID-attribute, we can change the value of their parameters
- We can change the value of the color-parameter of the red circle by:

```
lights.setValue(
    "red",
    "color",
    "ff0000");
```

Waiting for User Input

- Whenever a user clicks on the green circle, an event is sent
- We can listen for events using:

```
lights.getNextEvent();)
```

So Far, We Have Seen. . .

. . . how to use the SceneBeans animation object; in particular how to:

- create animation-description files
- load animation-description files
- invoke commands in the animation
- set parameters in the animation
- listen for events from the animation

More on SceneBeans

- The Telebit example from the start of the talk is created using the SceneBeans animation object
- Visit SceneBeans' homepage[a] for more information on writing animation-description files

[a] http://www-dse.doc.ic.ac.uk/Software/SceneBeans/

Overview

- Architecture
- Hello World
- Dining Philosophers
- Stop Signal
- A closer look at ShowModal $\Leftarrow$
- Future work & conclusion

A Closer Look at ShowModal

- It is easy to create an animation object:
  1. Create a Java class implementing a certain interface
  2. Generate appropriate ML code using `rmicompiler`

Petri-net Based Prototyping (1/2)

- Using JBuilder, a very rough outline of a dialog is created
- A couple accessor methods are added
- Using the `rmicompiler`, an ML interface is created
- In 15 minutes, a nice dialog can be used from a net

Petri-net Based Prototyping (2/2)

- This way it is easy to get input and present output
- We use Petri-nets to “program” the control flow
- Combining this, we obtain executable prototypes in a very easy manner

BRITNeY animation ↔ MIMIC/CPN

MIMIC/CPN	BRITNeY animation
very general and low-level	encourages use of domain-specific, high-level animation objects[a]
animations can be designed using a GUI	(currently) no such feature
synchronous only	asynchronous features designed
extended by ML libraries	extended by ML libraries or by creating new animation objects in Java

[a] But a number of quite general animation objects exist

Overview

- Architecture
- Hello World
- Dining Philosophers
- Stop Signal
- A closer look at ShowModal
- Future work & conclusion $\Leftarrow$

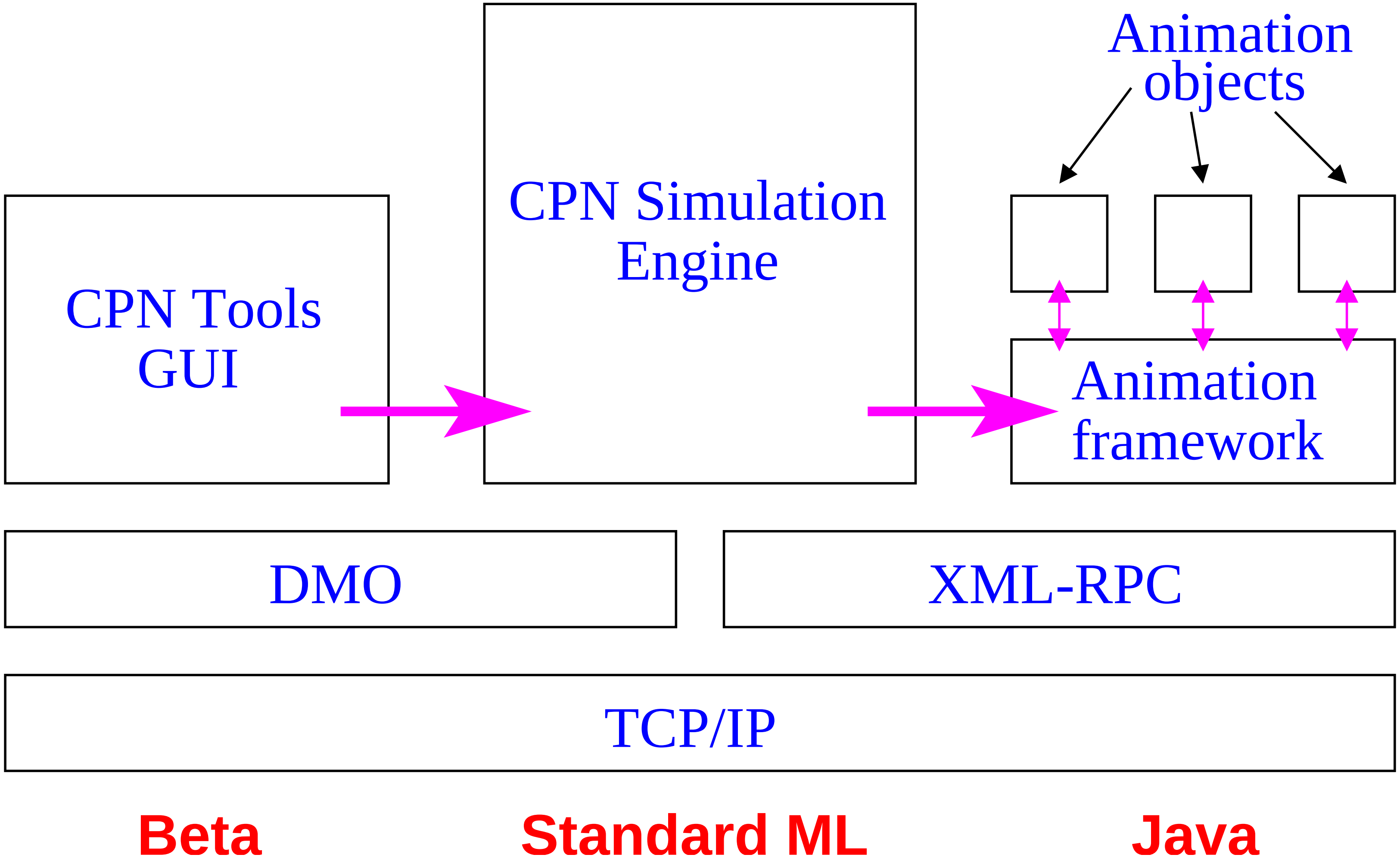
Future Work

- Clean up and make 1^{st} release
- Implementaiton of more animation objects
- New architecture

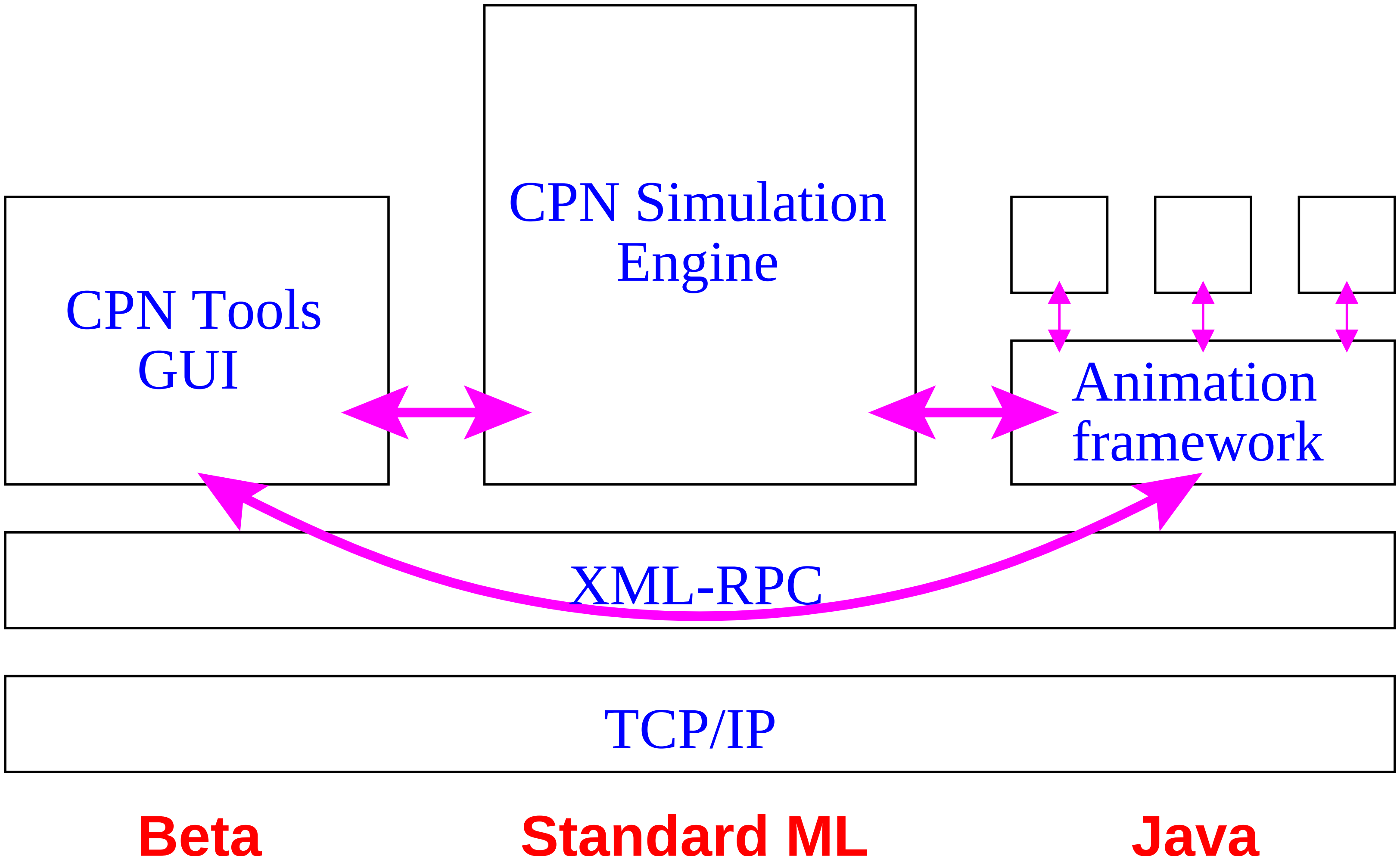
More Animation Objects

- Message sequence charts
- Charts (for use with e.g. the performance facilities)
- Report generator (to create nice simulation/state-space reports)
- Framemork for Petri-net based rapid prototyping
- PNVis (Kindler & Páles: *3D-Visualization of Petri Net Models*)
- . . .

Current Architecture



New Architecture



Benefits of the New Architecture

- The simulation can be controlled better from the animation, by e.g. adding tokens to a place $\Longrightarrow$ the animation can run without the CPN Tools GUI
- Simulation can be started and stopped from the animation package
- Certain animations may be shown directly in the CPN Tools GUI
- Certain animations may be defined in CPN Tools and exported to the animation tool

Summary

During this talk, we have seen

- How to create connections to animation objects
- A number of different animation objects
  - ShowModal
  - GetString
  - GraphSheet
  - SceneBeans
- How to use animations with nets
  - in code-fragments
  - to create extension-libraries