A Decentralized Approach for Programming Interactive Applications with JavaScript and Blockly

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October 2012

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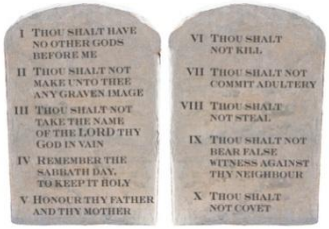
Basic idea of behavioral programming

Develop complex software systems

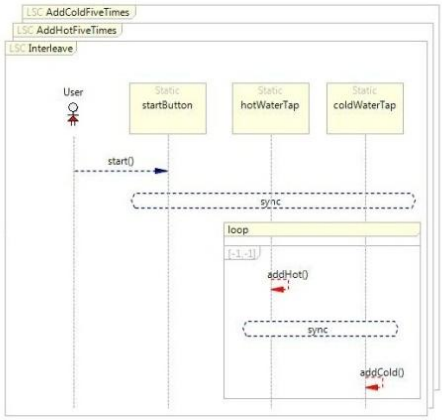
from simple specifications of required behavior



- ✓ You shall do …
- ✓ You shall not do …
- ✓ . . .

that are interwoven automatically

From required behavior to code



LSC: A visual language for scenario specification

- Damm and Harel 2001, Harel and Marelly 2003
- Natural yet executable
- For requirement specification and for programming
- IDEs – PlayGo, Play Engine

BPJ: A package for programming scenarios in Java

```
class AddHotFiveTimes extends BThread {
    public void runBThread() {
        for (int i=1; i<=5; i++) {
            bSync(addHot, none, none);
        }
    }
}
```

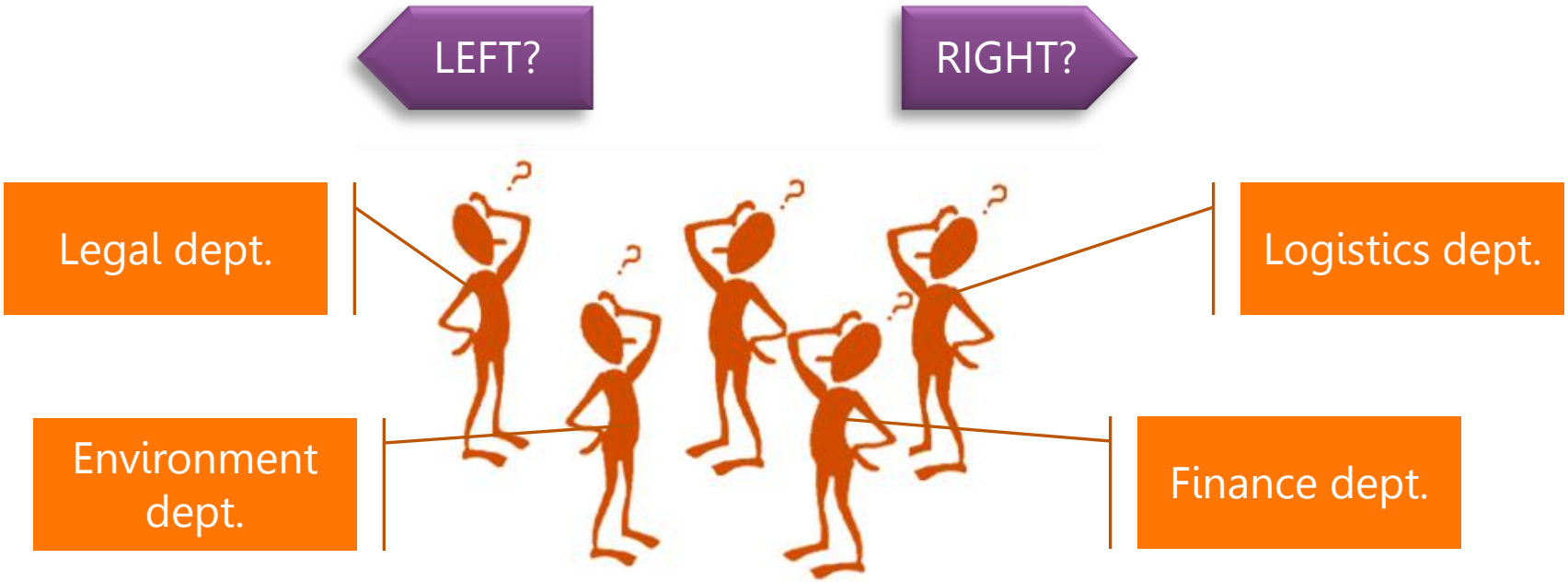
- Harel, Marron, and Weiss 2010
- Programming scenarios in standard languages
- Integrate with & complement other paradigms (OOP, aspects, rule-based, agile, …).

Now also in **C, C++, Erlang, JavaScript and Blockly**

The basic idea of BP

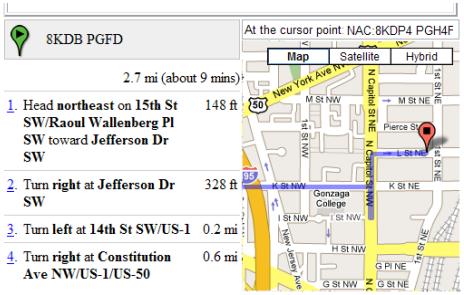
At every decision point in execution different components represent different facets of the next decision

A general interweaving mechanism collects and evaluates the information and then makes a decision



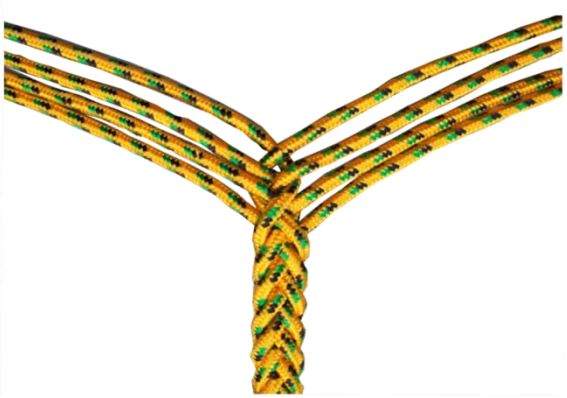
Requesting and blocking allow humans to interweave processes in their head

Route



- Go for 90 km on road A1
- Turn left to road A4
- Go for 70 km on road A4
- . . .

+



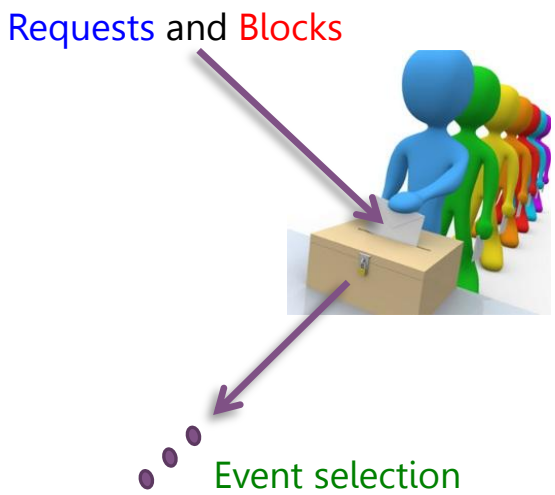
Schedule

- . . .
- Drive for 4 hours
- Stop for lunch
- Drive for 3 hours
- Look for a hotel
- Stop for the night

= Trip

Behavior execution cycle

1. Behavior threads (b-threads) post declarations:
   - Request events
   - Wait for events
   - Block events

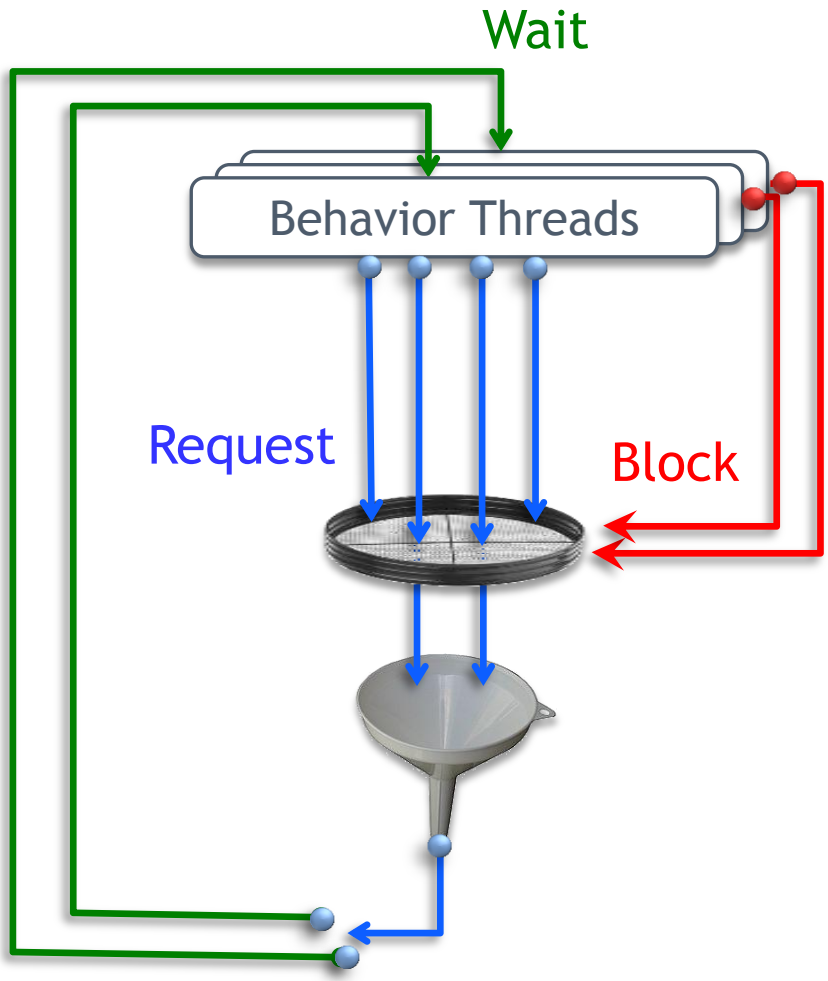


2. When all declarations are collected:

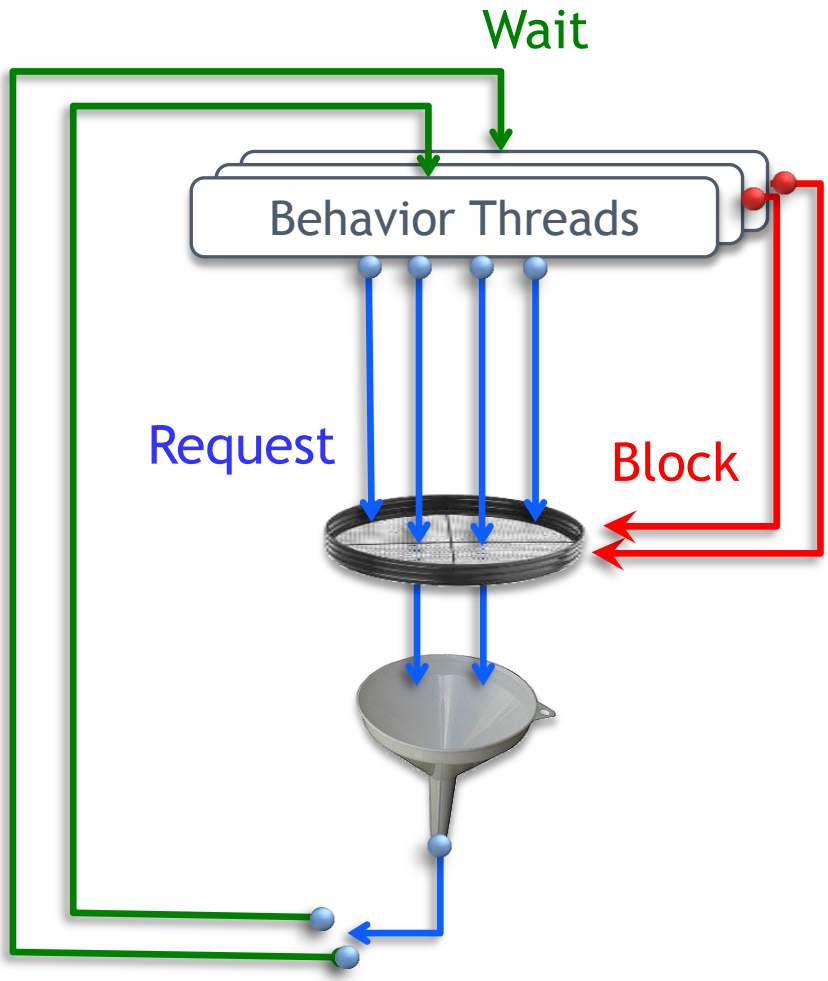
   An event **is selected** that is **requested** and not **blocked**.

   B-threads **waiting** for or **requesting** the event are **notified**

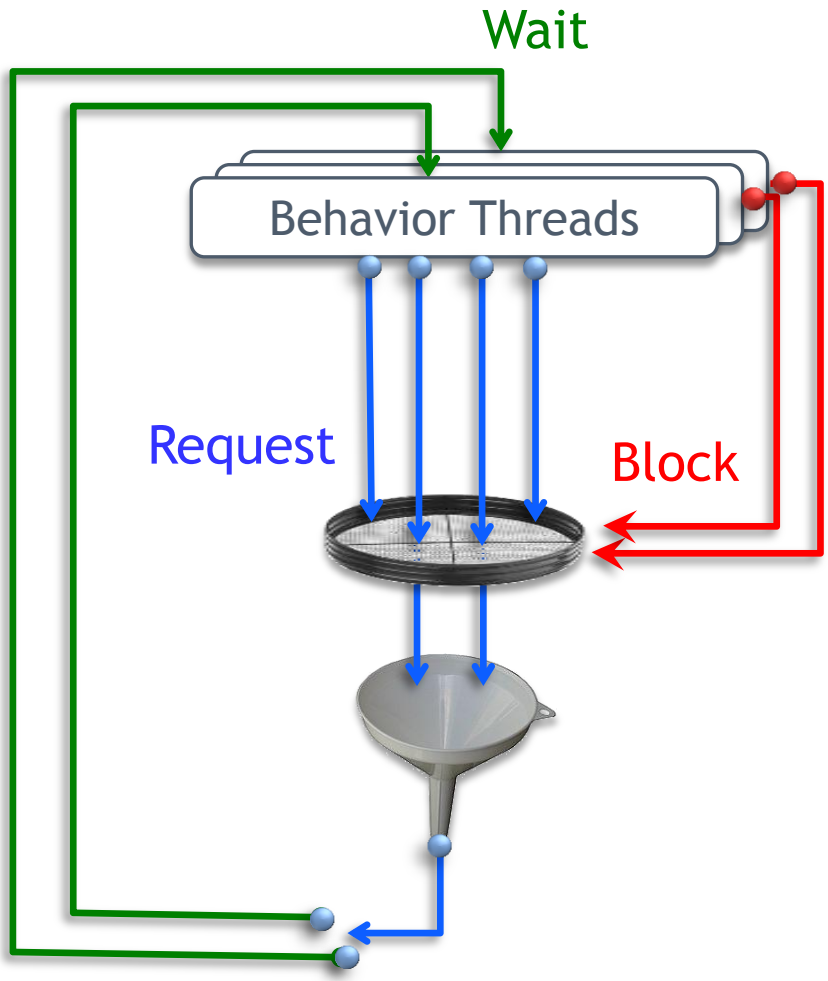
Behavior execution cycle



Behavior execution cycle



Behavior execution cycle



Interweaving programmed scenarios

```
AddHotFiveTimes() {
   for i=1 to 5 {
      bSync(request=addHot, wait-for=none, block=none);
   }
}
```

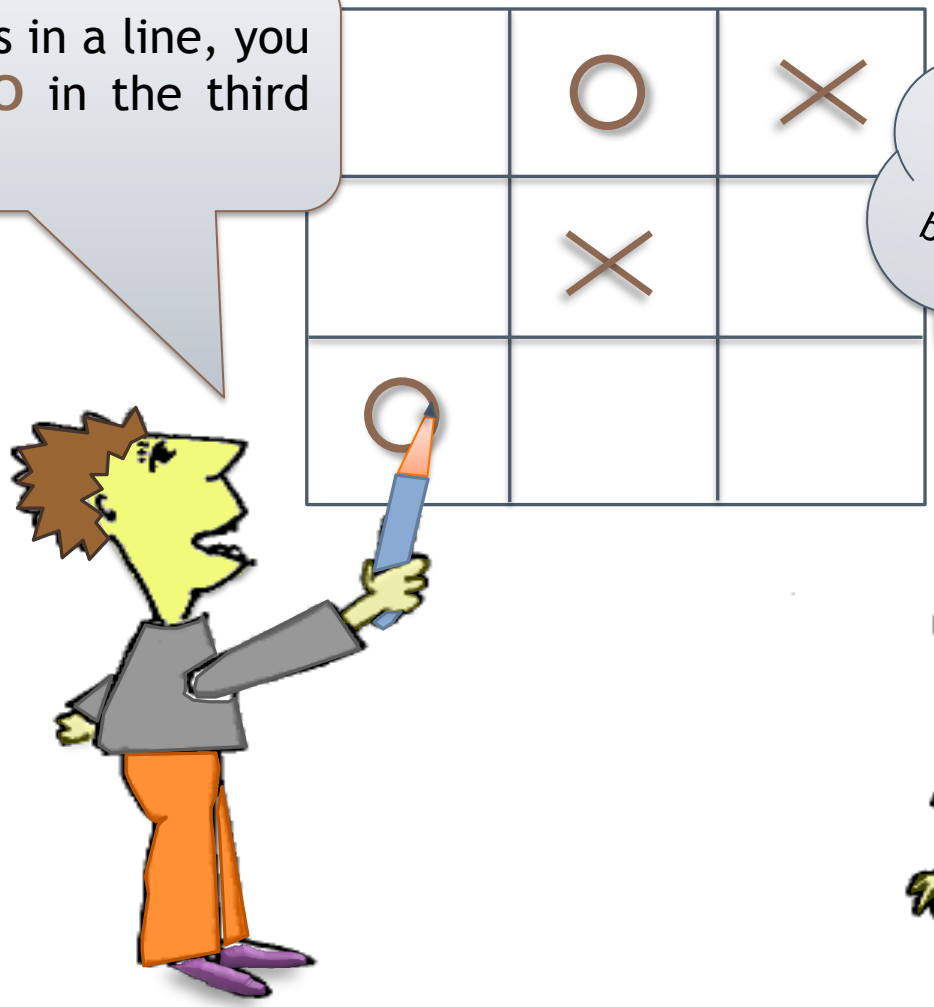
```
AddColdFiveTimes() {
   for i=1 to 5 {
      bSync(request=addCold, wait-for=none, block=none);
   }
}
```

```
Interleave() {
   forever {
      bSync(request=none, wait-for=addHot, block=addCold);
      bSync(request=none, wait-for=addCold, block=addHot);
   }
}
```

addHot
addCold
addHot
addCold
addHot
addCold
addHot
addCold
addHot
addCold

Alignment of code modules with requirements

When I put two Xs in a line, you need to put an O in the third square



A program playing Tic-Tac-Toe

```
EnforceTurns() {
  forever {
    bSync(request=none, wait-for=XMove, block=OMove);
    bSync(request=none, wait-for=OMove, block=XMove);
  }
}
```

⋮

```
DetectTie() {
  for i = 1 to 9 {
      bSync(request=none, wait-for=AnyMove, block=none);
  }
  bSync(request=DeclareTie,  wait-for=none, block=none);
}
```

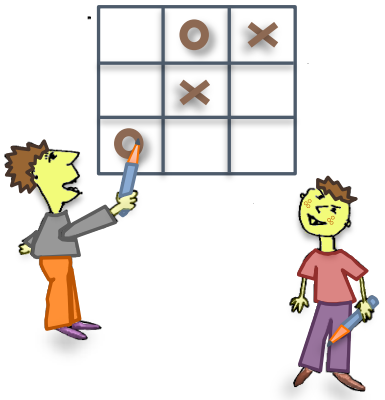
Rules of the game

⋮

```
AddThirdO () {
      bSync(request=none, wait-for=O⟨1,3⟩, block=none);
      bSync(request=none, wait-for=O⟨2,2⟩, block=none);
      bSync(request=O⟨3,1⟩, wait-for=none, block=none);
}
```

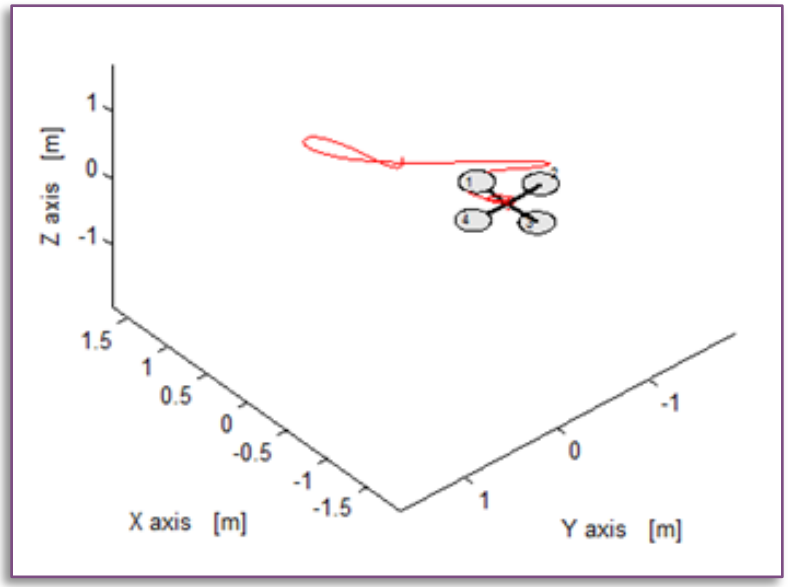
⋮

```
PreventThirdX() {
      bSync(request=none, wait-for=X⟨1,3⟩, block=none);
      bSync(request=none, wait-for=X⟨2,2⟩, block=none);
      bSync(request=O⟨3,1⟩, wait-for=none, block=none);
}
```



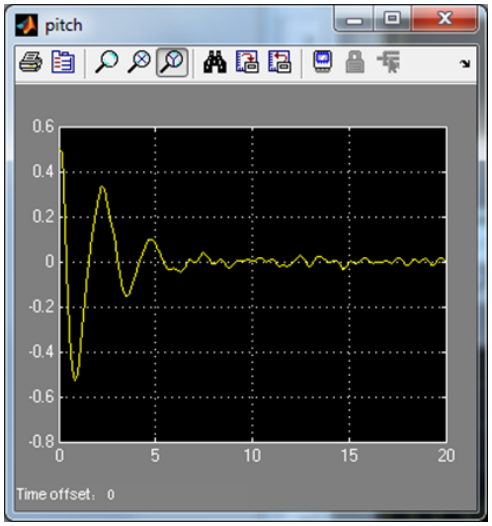
Strategies

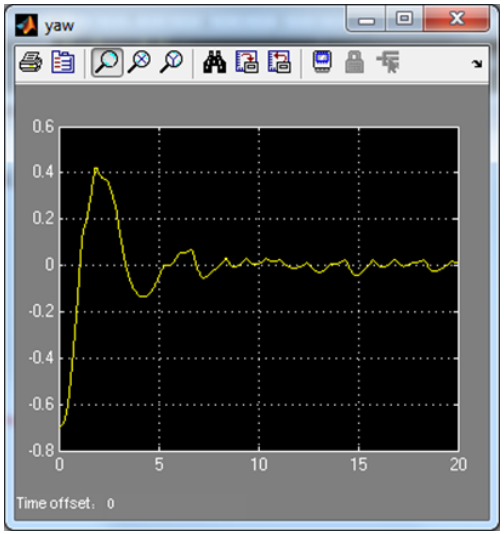
Stabilizing a quadrotor - behaviorally

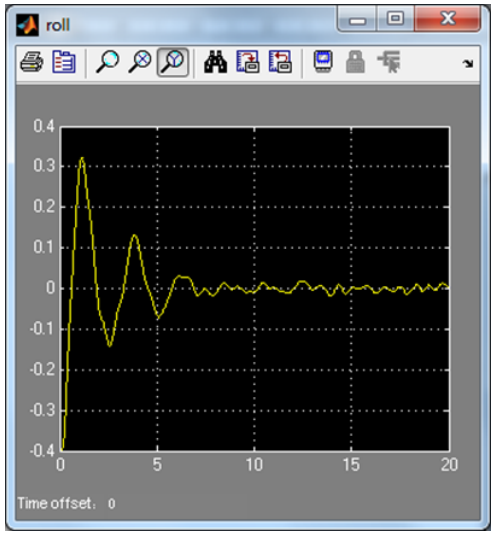


Results of applying the quadrotor Simulink model of Bouabdalla et al where a linear transformation box is replaced with behavior threads.

Pitch, yaw and roll angles are stabilized after a few seconds.







Behavioral Scripts in JavaScript
Synchronization and Event Selection

bSync implemented as `yield` - available in JS 1.7 (on Firefox)

```
bp.addBThread('Add hot five times',
priority++, function() {
        for (x = 1; x <= 5; x++) {
                yield({ request: ['addHot'],
                        wait: [],
                        block: []
                });
        }
});
```

Behavioral Scripts in JavaScript
Sensors and Actuators

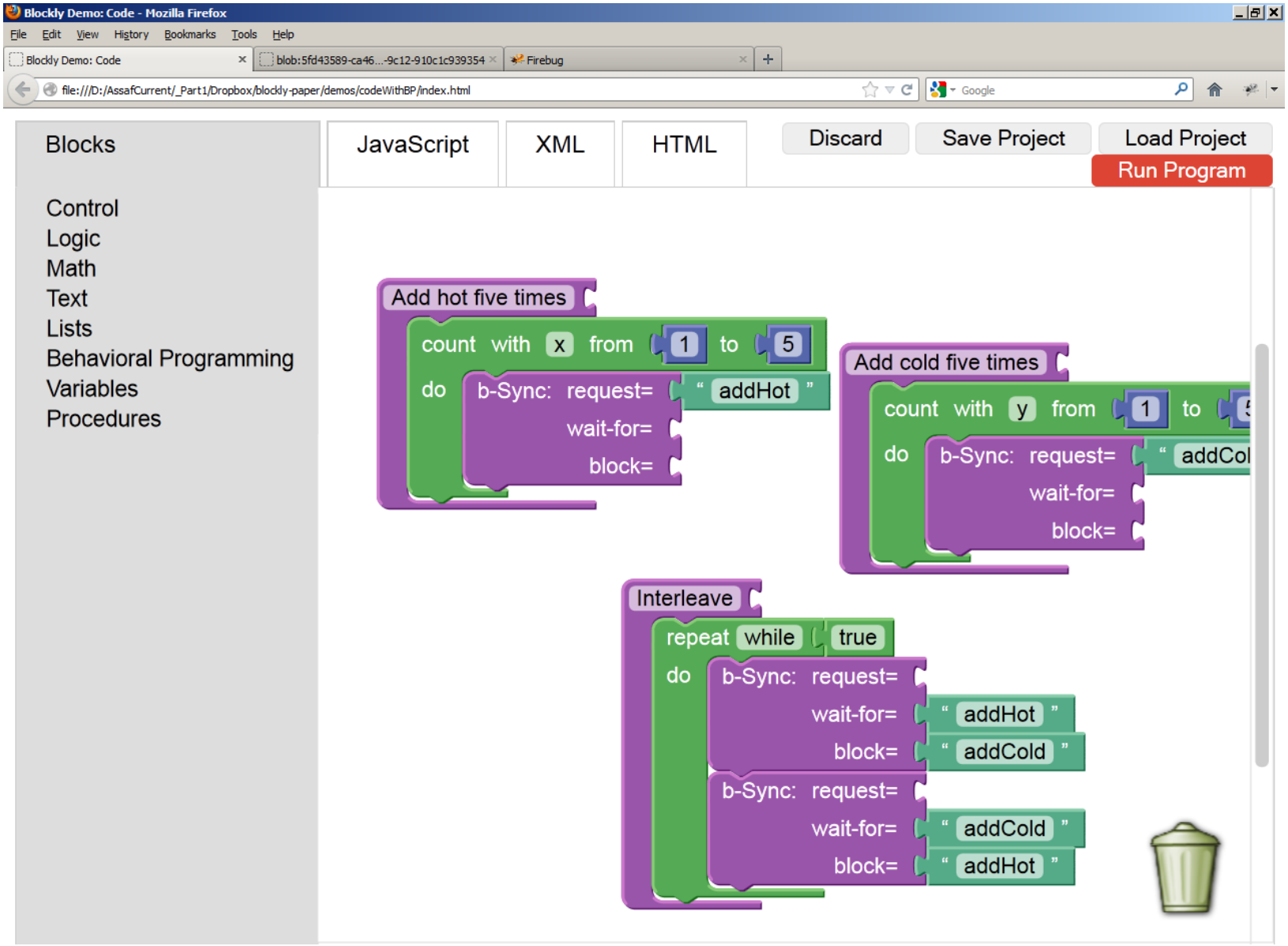
```
<input
    value="StartGame"
    type="button"
    onclick="trigger('StartGame');"
    style="position:relative;background-color:LightPink;"
/>
```

```
<center style="font-size: x-large"

 when_addHot  = 'innerHTML+="<span …>addHot</span><br>"'

 when_addCold = 'innerHTML += "<span …">addCold</span><br>"'
>
```

BP in Google's Blockly



DEMO

Benefits of Programming behaviorally

NATURAL DEVELOPMENT

Small parallel scenarios are natural

Incrementality developed

No need for complex state management

Implementing scenario-based programming in languages such as JavaScript allows for integration with other programming metaphors

Each new required behavior

(or game rule, or strategy, etc.)

is added in a separate b-thread

without changing existing code

Research

- Programming languages and idioms
- Compositional model-checking and verification
- Adaptivity and learning
- Automatic repair
- Comprehension and visualization
- Programming platforms
- Applications in robotics and hybrid control
- Natural language
- Performance and scalability
- . . .

Team members

Past and present – more or less in chronological order – updated 6/2012.

- **David Harel (*)**
- Rami Marelly
- Hillel Kugler
- Shahar Maoz
- Itai Segall
- Yoram Atir
- Asaf Kleinbrot
- Dan Barak
- Avital Sadot
- Amir Kantor
- Michal Gordon
- Tal Berger
- Smadar Szekely (*)
- Assaf Marron (*)
- Gera Weiss (*)
- Daniel Barkan
- Guy Weiss
- Yaarit Natan
- Amir Nissim
- Robby Lampert
- Guy Wiener
- Yaniv Sa'ar
- Nir Eitan
- Guy Katz
- Michael Bar-Sinai
- Moshe Weinstock
- Ronen Brafman

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(*) contact persons for the team

Behavioral Programming
A language-independent approach to natural incremental development

For systems where complexity stems from the need to coordinate multiple simple behaviors