OFFIS Energy
INSTITUTE FOR INFORMATION TECHNOLOGY

Discrete-event simulation with SimPy

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2002:

Started by *Klaus G. Müller* and *Tony Vignaux*

2008:

Ontje Lünsdorf's and my first contributions

2011:

Ontje and I became project maintainers

2013:

SimPy 3 released

Environment

Process

Event

Resource

Event loop

Task / Coroutine

Future / Promise / Deffered

Semaphore

Generator functions for modeling processes

```
>>> def generator(x):
...     y = yield x + 1
...     return y + 1
...
>>> g = generator(1)
>>> next(g)
2
>>> g.send(3)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
StopIteration: 4
```

```
>>> import simpy
>>>
>>> def clock(env, name, tick):
...     while True:
...         print(name, env.now)
...         yield env.timeout(tick)
...
>>> env = simpy.Environment()
>>>
>>> env.process(clock(env, 'fast', 0.5))
<Process(clock) object at 0x...>
>>> env.process(clock(env, 'slow', 1))
<Process(clock) object at 0x...>
>>>
>>> env.run(until=2)
fast 0
slow 0
fast 0.5
slow 1
fast 1.0
fast 1.5
```

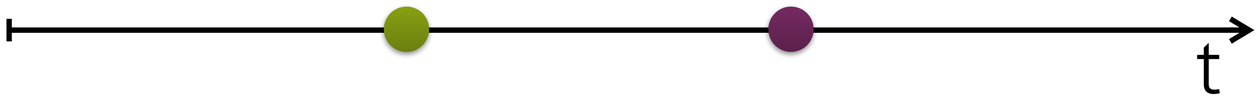
Environment

simulate “as fast as possible“

RealtimeEnvironment

synchronized with wall-clock time

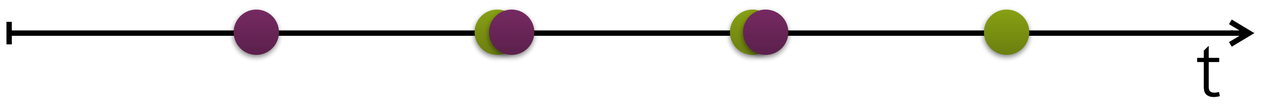
Timeout events let time pass




```
def speaker(env, start):
    until_start = start - env.now
    yield env.timeout(until_start)

    yield env.timeout(30)
```

Image stolen from http://xkcd.com/785/

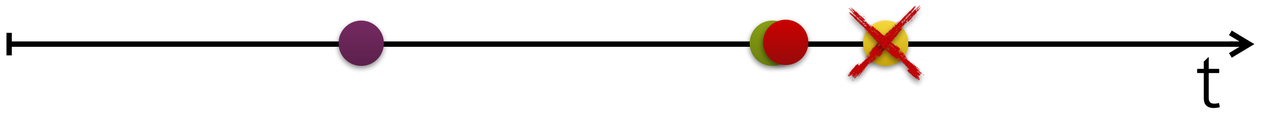
Processes are events, too




```
def speaker(env):
    yield env.timeout(30)
    return 'handout'


def moderator(env):
    for i in range(3):
        val = yield env.process(speaker(env))
        print(val)
```

Image stolen from http://xkcd.com/785/

Asynchronous interrupts




```
def speaker(env):
    try:
        yield env.timeout(randint(25, 35))
    except simpy.Interrupt as interrupt:
        print(interrupt.cause)


def moderator(env):
    for i in range(3):
        speaker_proc = env.process(speaker(env))
        yield env.timeout(30)
        speaker_proc.interrupt('No time left')
```

Image stolen from http://xkcd.com/785/

Condition events

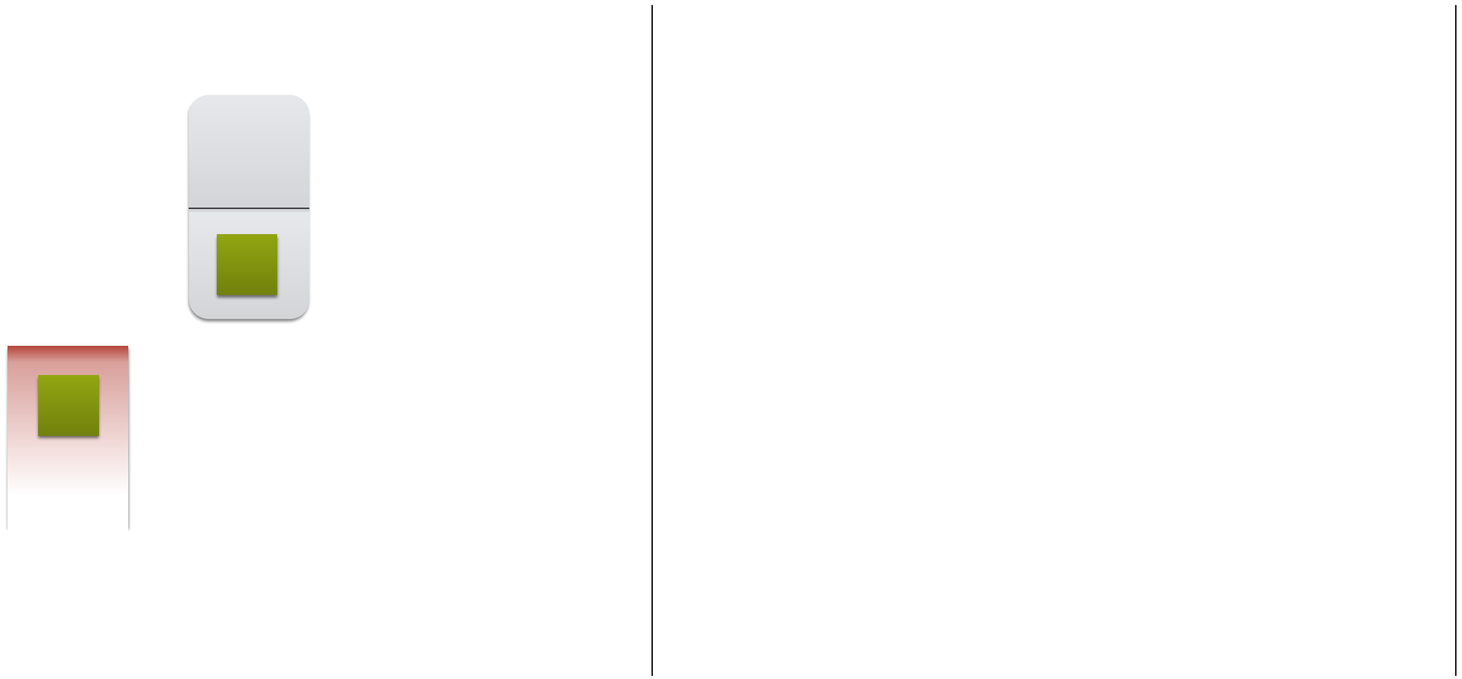

```
def speaker(env):
    try:
        yield env.timeout(randint(25, 35))
    except simpy.Interrupt as interrupt:
        print(interrupt.cause)


def moderator(env):
    for i in range(3):
        speaker_proc = env.process(speaker(env))
        results = yield speaker_proc | env.timeout(30)

        if speaker_proc not in results:
            speaker_proc.interrupt('No time left')
```

Image stolen from http://xkcd.com/785/

Shared resources

Shared resources

Resource



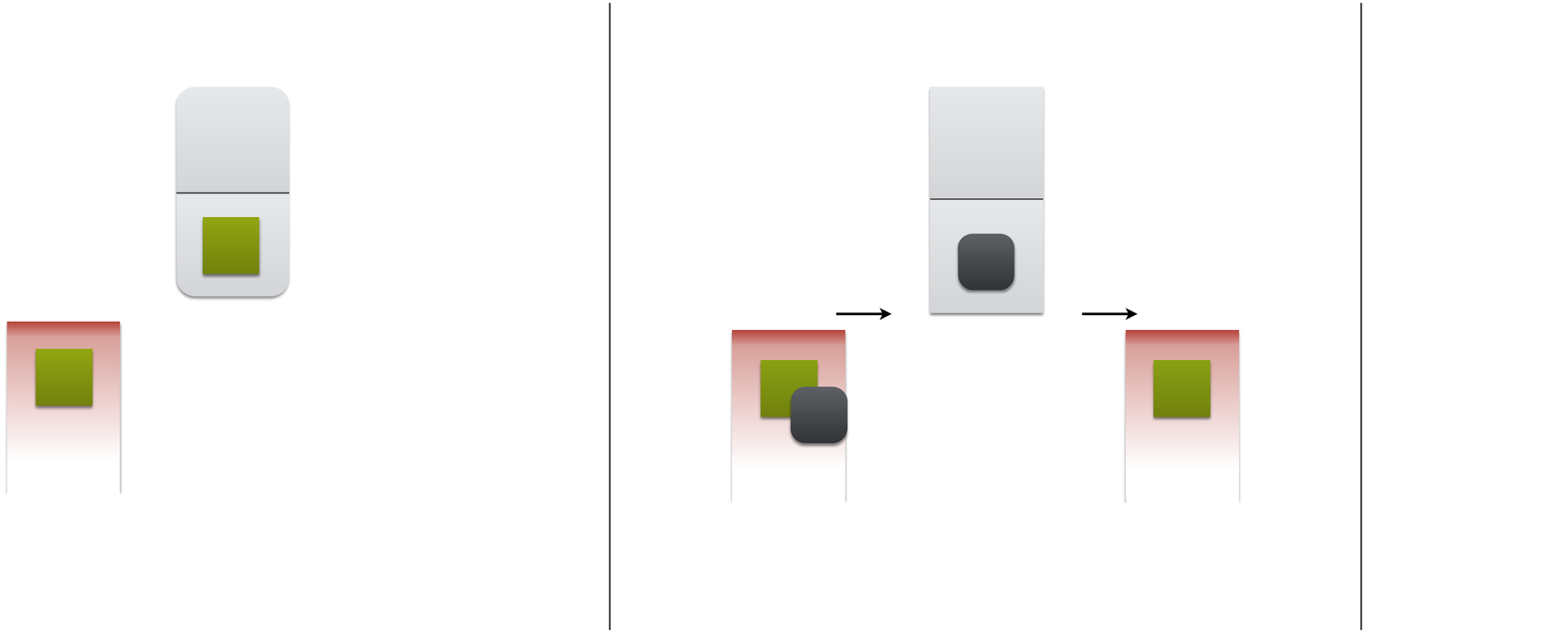
Queue

Process

Shared resources

Resource

Store



Queue

Process

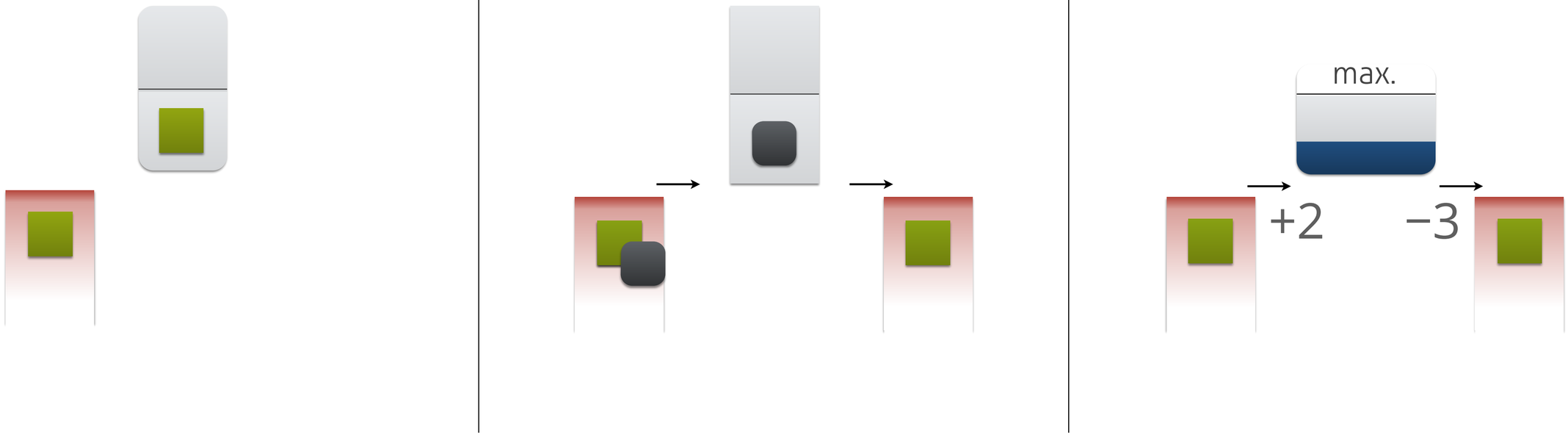
Object

Shared resources

Resource

Store

Container



Queue Process Object

Example:
Conference Attendee

Photo: Thomas Massmann, http://www.flickr.com/photos/it-spirit/

imports

```
from random import randint
import simpy
```

config

```
TALKS_PER_SESSION = 3
TALK_LENGTH = 30
BREAK_LENGTH = 15
```

repeat sessions

```
def attendee(env, name, knowledge=0, hunger=0):
    while True:
        # Visit talks
        for i in range(TALKS_PER_SESSION):
            knowledge += randint(0, 3) / (1 + hunger)
            hunger += randint(1, 4)

            yield env.timeout(TALK_LENGTH)

        print('Attendee %s finished talks with knowledge %.2f and hunger '
              '%.2f.' % (name, knowledge, hunger))
```

visit talks

take a break

```
        # Go to buffet
        food = randint(3, 12)
        hunger -= min(food, hunger)

        yield env.timeout(BREAK_LENGTH)

        print('Attendee %s finished eating with hunger %.2f' % (name, hunger))
```

run simulation

```
env = simpy.Environment()
for i in range(5):
    env.process(attendee(env, i))
env.run(until=220)
```

```
Attendee 0 finished talks with knowledge 3.48 and hunger 9.00.
Attendee 1 finished talks with knowledge 2.67 and hunger 5.00.
Attendee 2 finished talks with knowledge 4.08 and hunger 4.00.
Attendee 3 finished talks with knowledge 2.67 and hunger 5.00.
Attendee 4 finished talks with knowledge 0.33 and hunger 5.00.
Attendee 0 finished eating with hunger 0.00
Attendee 1 finished eating with hunger 1.00
Attendee 2 finished eating with hunger 0.00
Attendee 3 finished eating with hunger 0.00
Attendee 4 finished eating with hunger 0.00
Attendee 0 finished talks with knowledge 4.38 and hunger 7.00.
Attendee 1 finished talks with knowledge 4.29 and hunger 10.00.
Attendee 2 finished talks with knowledge 7.62 and hunger 10.00.
Attendee 3 finished talks with knowledge 6.20 and hunger 10.00.
Attendee 4 finished talks with knowledge 3.67 and hunger 7.00.
Attendee 0 finished eating with hunger 0.00
Attendee 1 finished eating with hunger 0.00
Attendee 2 finished eating with hunger 7.00
Attendee 3 finished eating with hunger 6.00
Attendee 4 finished eating with hunger 0.00
```

Example:
Conference Attendee at the Buffet

Photo: Thomas Massmann, http://www.flickr.com/photos/it-spirit/

more config

same as before

try to get to the buffet in time

got to the buffet

onoes!

wait

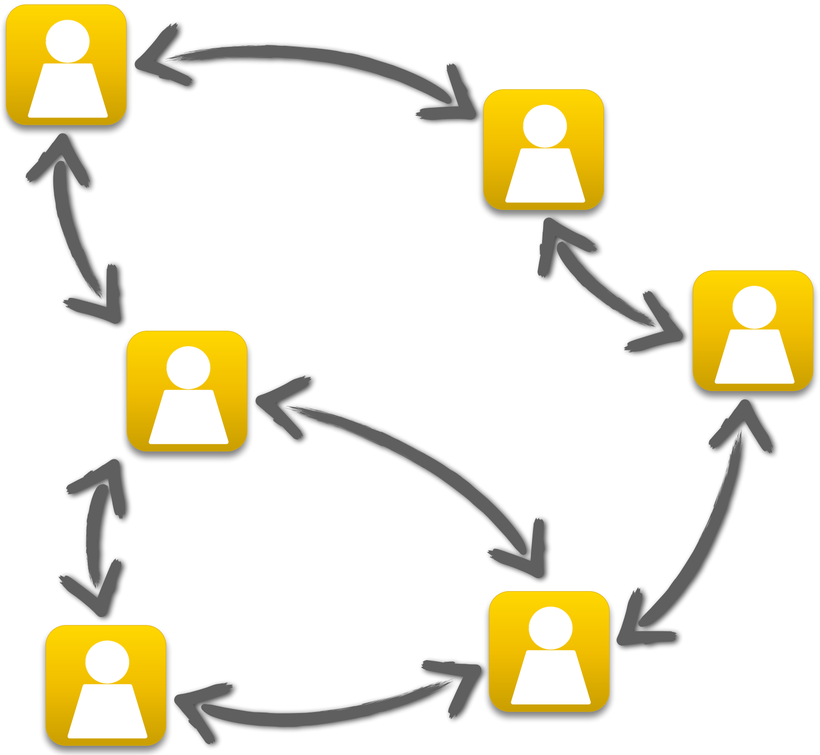
run simulation

```
[...]
DURATION_EAT = 3
BUFFET_SLOTS = 1

def attendee(env, name, buffet, knowledge=0, hunger=0):
    while True:
        # Visit talks
        [...]

        # Go to buffet
        start = env.now
        with buffet.request() as req:
            yield req | env.timeout(BREAK_LENGTH - DURATION_EAT)
            time_left = LEN_BREAK - (env.now - start)

            if req.triggered:
                food = min(randint(3, 12), time_left)  # Less time -> less food
                yield env.timeout(DURATION_EAT)
                hunger -= min(food, hunger)
                time_left -= DURATION_EAT
                print('Attendee %s finished eating with hunger %.2f' %
                      (name, hunger))
            else:
                hunger += 1  # Penalty for only taking a look at all the food.
                print('Attendee %s didn't make it to the buffet, hunger is now '
                      'at %.2f.' % (name, hunger))

        yield env.timeout(time_left)


env = simpy.Environment()
buffet = simpy.Resource(env, capacity=BUFFET_SLOTS)
for i in range(5):
    env.process(attendee(env, i, buffet))
env.run(until=220)
```

```
Attendee 0 finished talks with knowledge 1.33 and hunger 9.00.
Attendee 1 finished talks with knowledge 2.00 and hunger 5.00.
Attendee 2 finished talks with knowledge 3.20 and hunger 11.00.
Attendee 3 finished talks with knowledge 2.50 and hunger 5.00.
Attendee 4 finished talks with knowledge 1.50 and hunger 6.00.
Attendee 0 finished eating with hunger 1.00
Attendee 1 finished eating with hunger 0.00
Attendee 2 finished eating with hunger 2.00
Attendee 3 finished eating with hunger 0.00
Attendee 4 didn't make it to the buffet, hunger is now at 7.00.
Attendee 0 finished talks with knowledge 5.42 and hunger 7.00.
Attendee 1 finished talks with knowledge 6.33 and hunger 5.00.
Attendee 2 finished talks with knowledge 7.68 and hunger 8.00.
Attendee 3 finished talks with knowledge 5.93 and hunger 8.00.
Attendee 4 finished talks with knowledge 2.14 and hunger 15.00.
Attendee 0 finished eating with hunger 0.00
Attendee 1 finished eating with hunger 2.00
Attendee 2 finished eating with hunger 0.00
Attendee 3 finished eating with hunger 2.00
Attendee 4 finished eating with hunger 10.00
```

simpy.io

Event-driven IO with
real and simulated TCP sockets



simpy.io

```
def client(env, client_sock):
    message = Message(env, client_sock)
    reply = yield message.send('ohai')
    print(reply)


def server(env, server_sock):
    # Accept new connection
    sock = yield server_sock.accept()
    message = Message(env, PacketUTF8(sock))

    # Get message and send reply
    request = yield message.recv()
    print(request.content)
    yield request.succeed('cya')
```

Plans for SimPy 3.x

- Keep the community happy :-)
- Minor optimizations
- Documentation improvements
- Helper functions for monitoring?

Final notes

- Easy to use and flexible
- Documentation, mailing list, tests
- Pure Python (2.7, 3.2+), no dependencies
  - PyPy supported
  - simpy-cython github.com/chaosmail/simpy-cython
  - SimSharp (SimPy in C#) github.com/abeham/SimSharp
- simpy.io for socket communication

bitbucket.org/simpy
simpy.rtfd.org

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