Using Lua for BACnet OEM solutions in building automation

How to brew coffee with Lua and BACnet

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SE Elektronic GmbH

Lua Workshop 2013

about SE Elektronic GmbH

- company founded 1983 (30 years)
- develops building automation products: sensors, actors, building controller
- development & production in south Germany

What is BACnet?

- Building Automation and Control Networks
- ASHRAE/ANSI 135-2010, ISO 16484-5
- Communication between devices and building management system
- Provide BMS with information
- Sensors, Actors
- AirConditioning, Elevators, Escalators, ...

<table>
<tr><td colspan="4">BACnet Application Layer</td></tr>
<tr><td colspan="4">BACnet Network Layer</td></tr>
<tr><td>BVLC</td><td>MS/TP</td><td>LON</td><td>PTP</td></tr>
<tr><td>UDP/IP</td><td>RS-485</td><td></td><td>RS-232</td></tr>
</table>

Why BACnet?
BACnet compared to other protocols

e.g. *Modbus*

- designed for resource limited devices
- master/slave communication
- read/write registers/file records
- datatypes limited (simple like integer, float)
- no data descriptions readable
  $\longrightarrow$ need device documentation for integration

Why BACnet?
BACnet compared to other protocols

BACnet

- data/features structured as objects
- developers like objects
- searches possible, objects browsable
- Event & ChangeOfValue Notifications
- BACnet network routable
- conformance tests $\longrightarrow$ cross-vendor interoperability

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- data/features structured as objects
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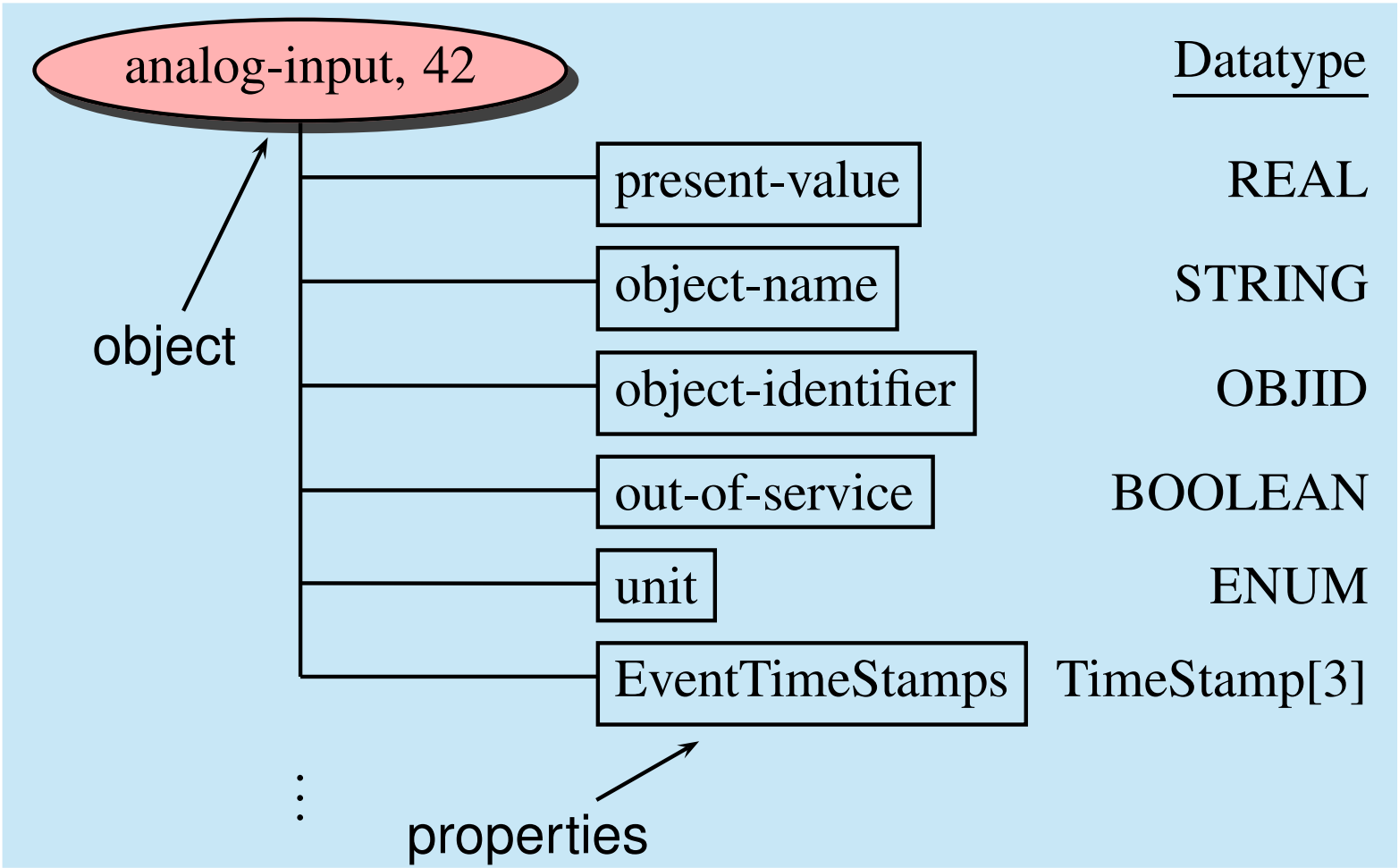
- BACnet network routable
- conformance tests $\longrightarrow$ cross-vendor interoperability
- high complexity
- many optional features
- stack partitioned into functional blocks

BACnet is all about objects



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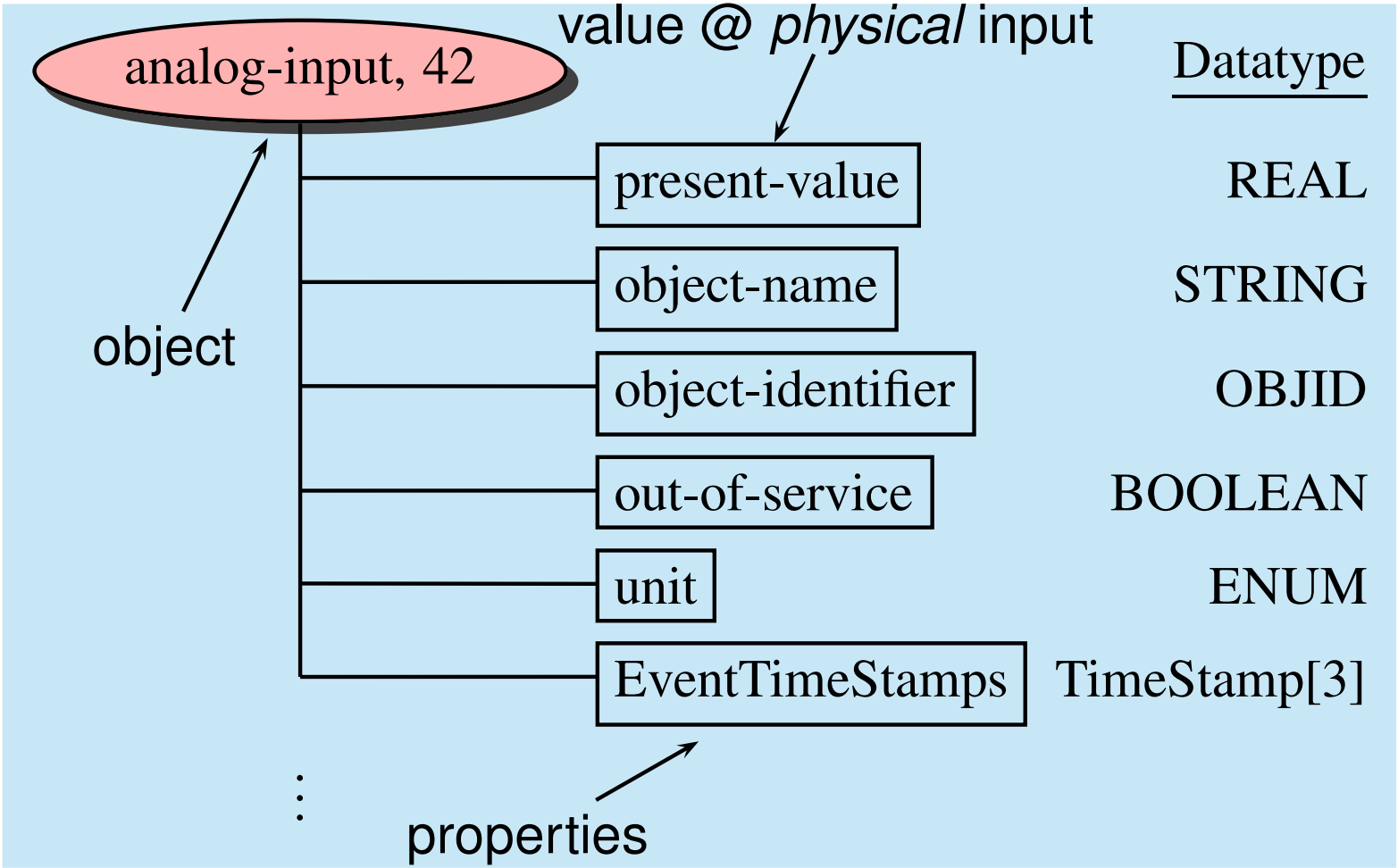

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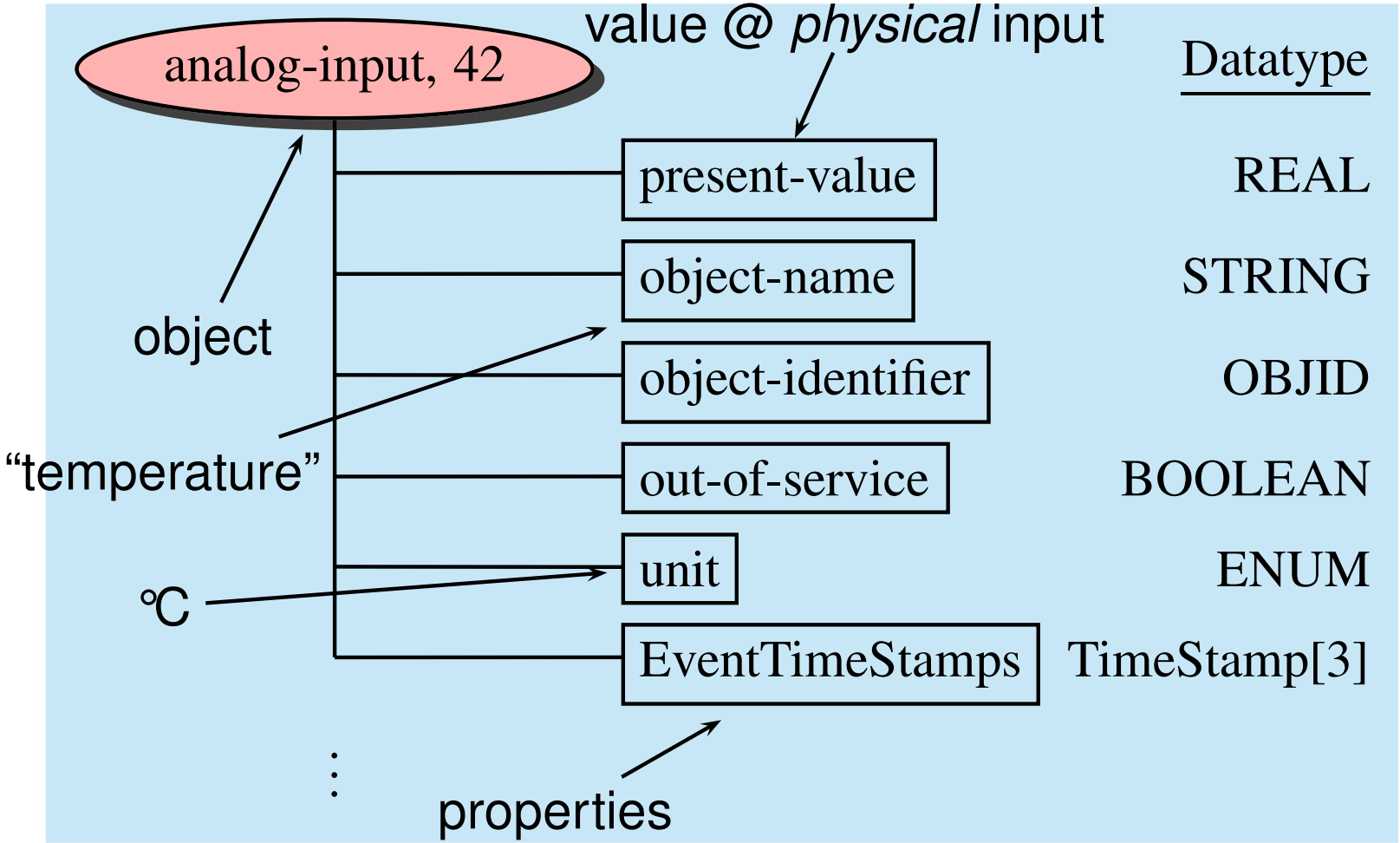

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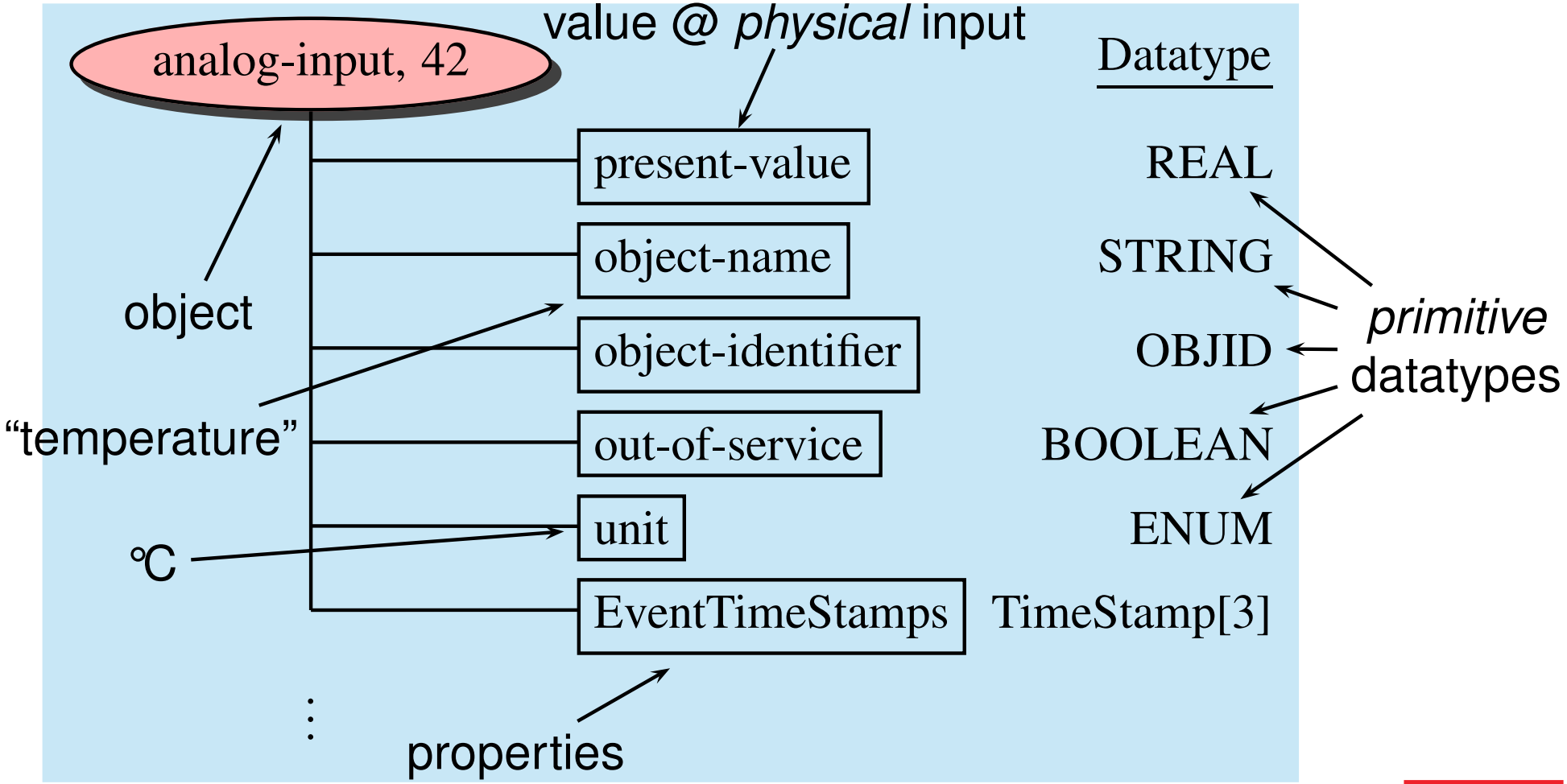

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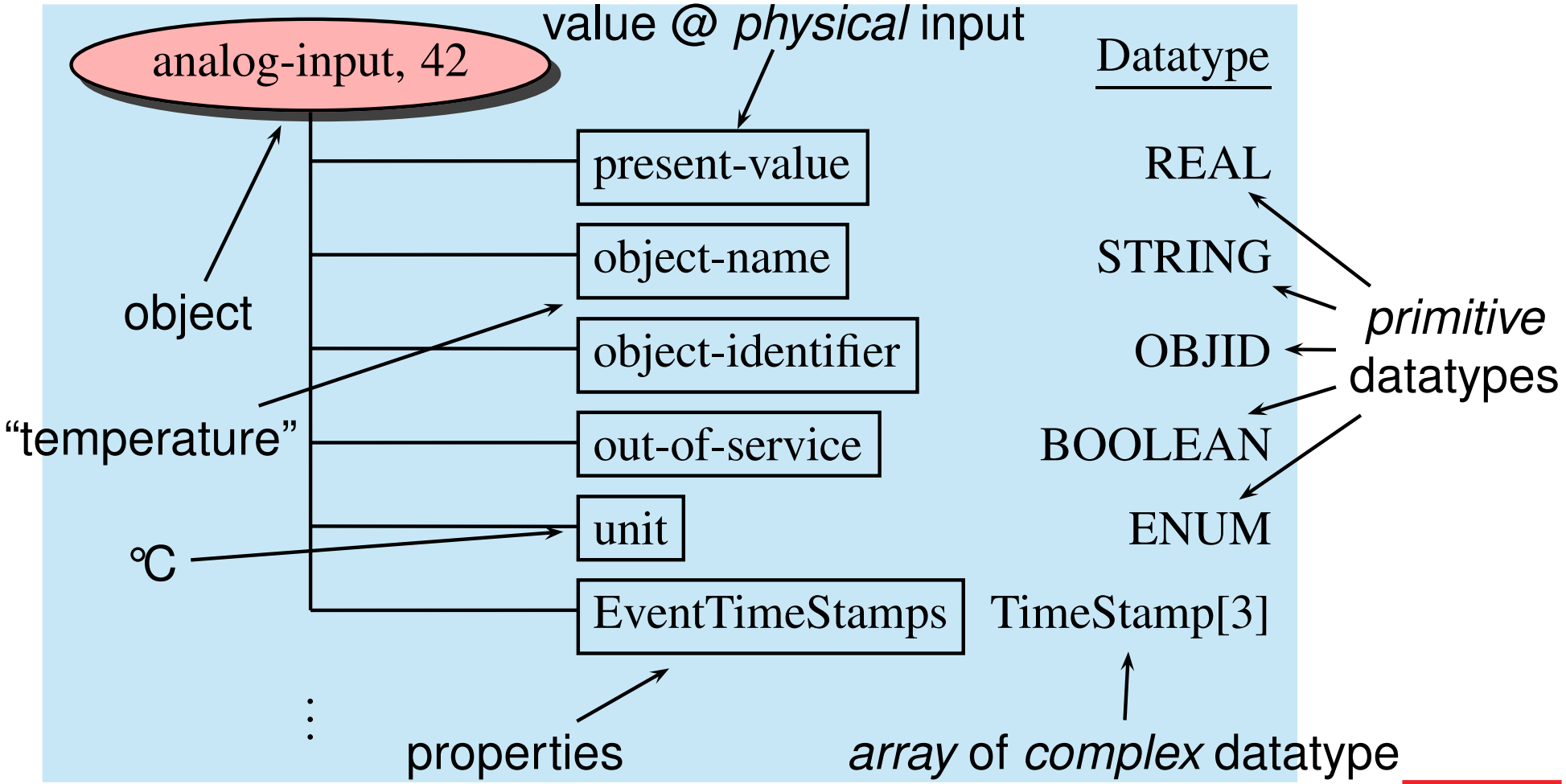

Application Layer

Communication Between Devices

- Object Access Services (Read, Write, Create, ...)
- Alarm & Event Services (EventNotification, ...)
- Device Management (Backup, Restore, ...)

The BACnet Coffee Machine

UberCoffee 2013™

BACnet Requirements

- full BACnet integration (Coffee Management System)
- control water temperature → Loop (PID)
- log coffee consumption → Trendlog

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- no more beans: send Email to Java™support

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- itegrated display with customizable content

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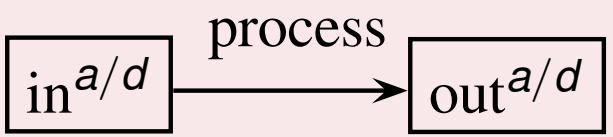
BACnet demands new processing strategies

Legacy Programmable Logic

- application w/ cyclic I/O:
  read - process - write
- data points (digital & analog)



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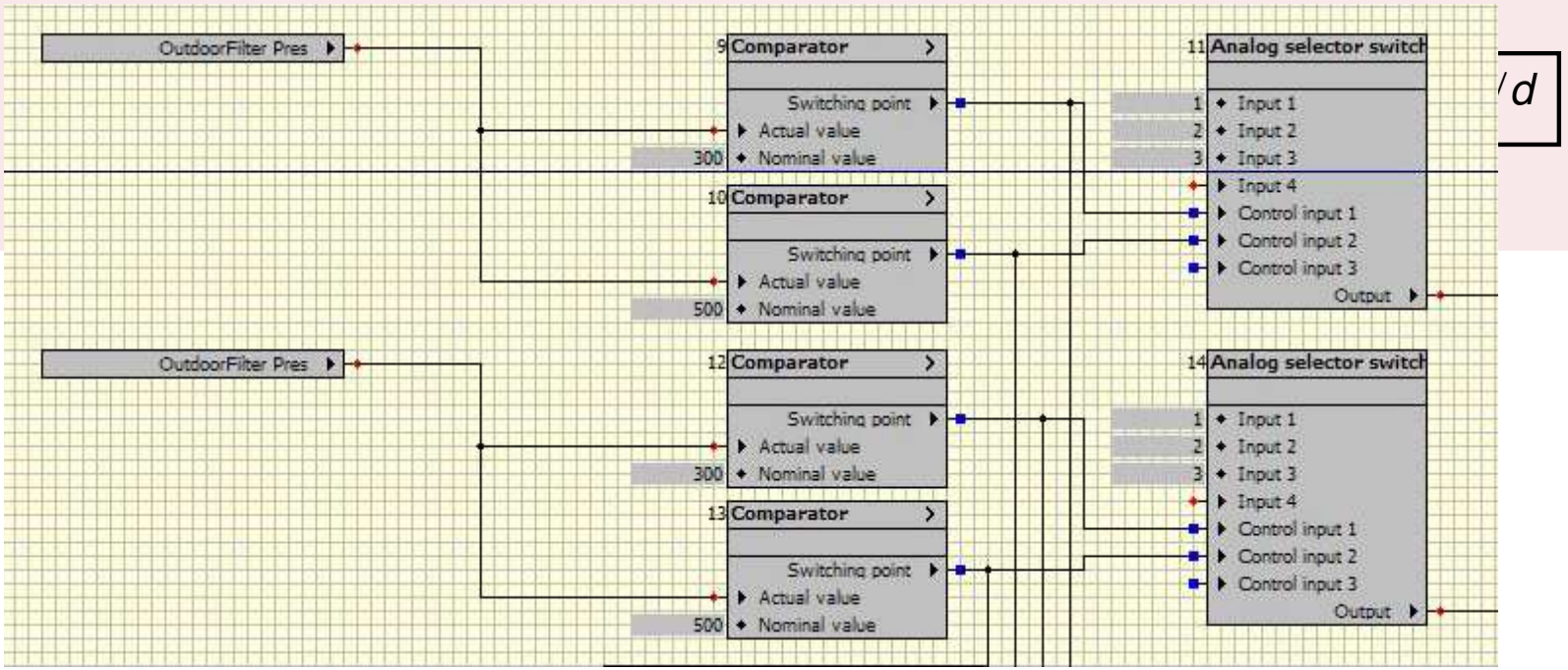

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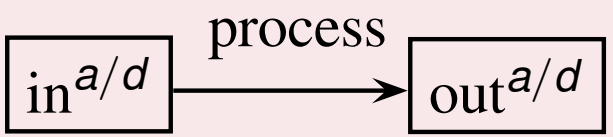

Problems

- translate between BACnet datatypes and data points
- impossible to read and/or modify complex properties
- can't use BACnet Notifications: ChangeOfValue & Events

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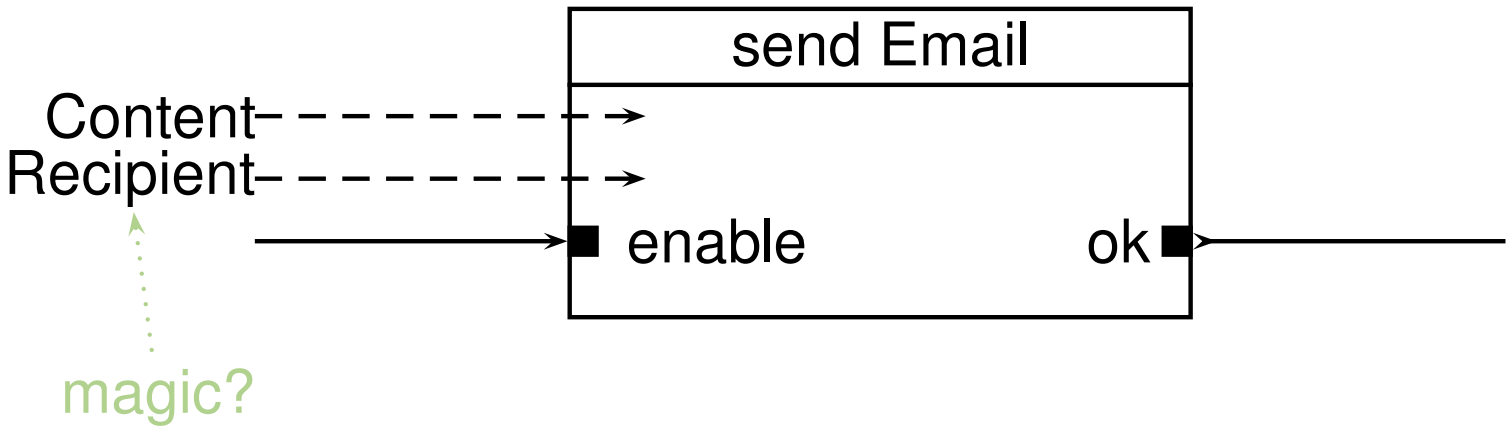
Legacy Solution

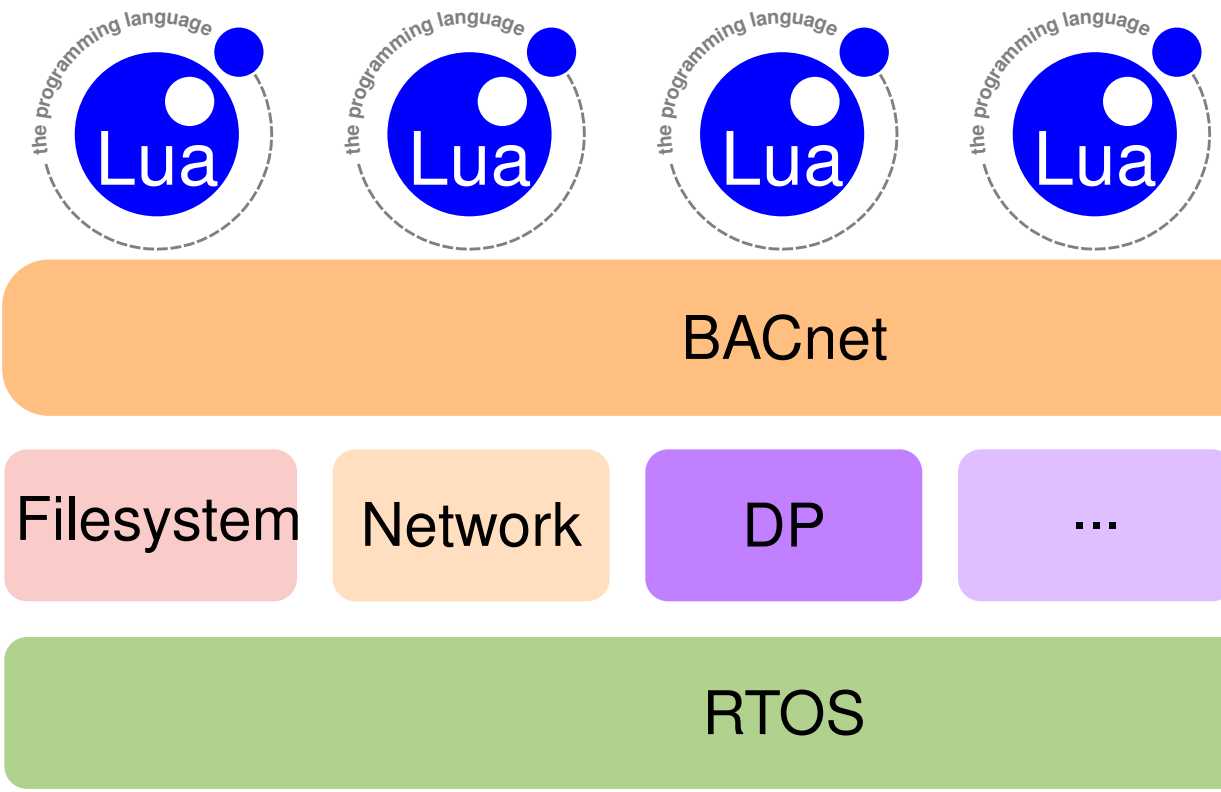
- create special data points/modules which trigger actions
- special (OEM) logic hardcoded in firmware



Solution

- Lua application for OEM tasks
- BACnet API for Lua
- BACnet datatypes for Lua
- asynchronous processing

Lua Program Object



Lua Program Object
Runtime

- Lua 5.2 VM
- Memory Quota $\longrightarrow$ restrict memory consumption
- Watchdog $\longrightarrow$ detect e.g. infinite loops
- Shell access and execution control via Telnet
- Loader for own package format
- is BACnet object $\longrightarrow$ configuration and control with BACnet

Lua Program Object
C-Libs/APIs

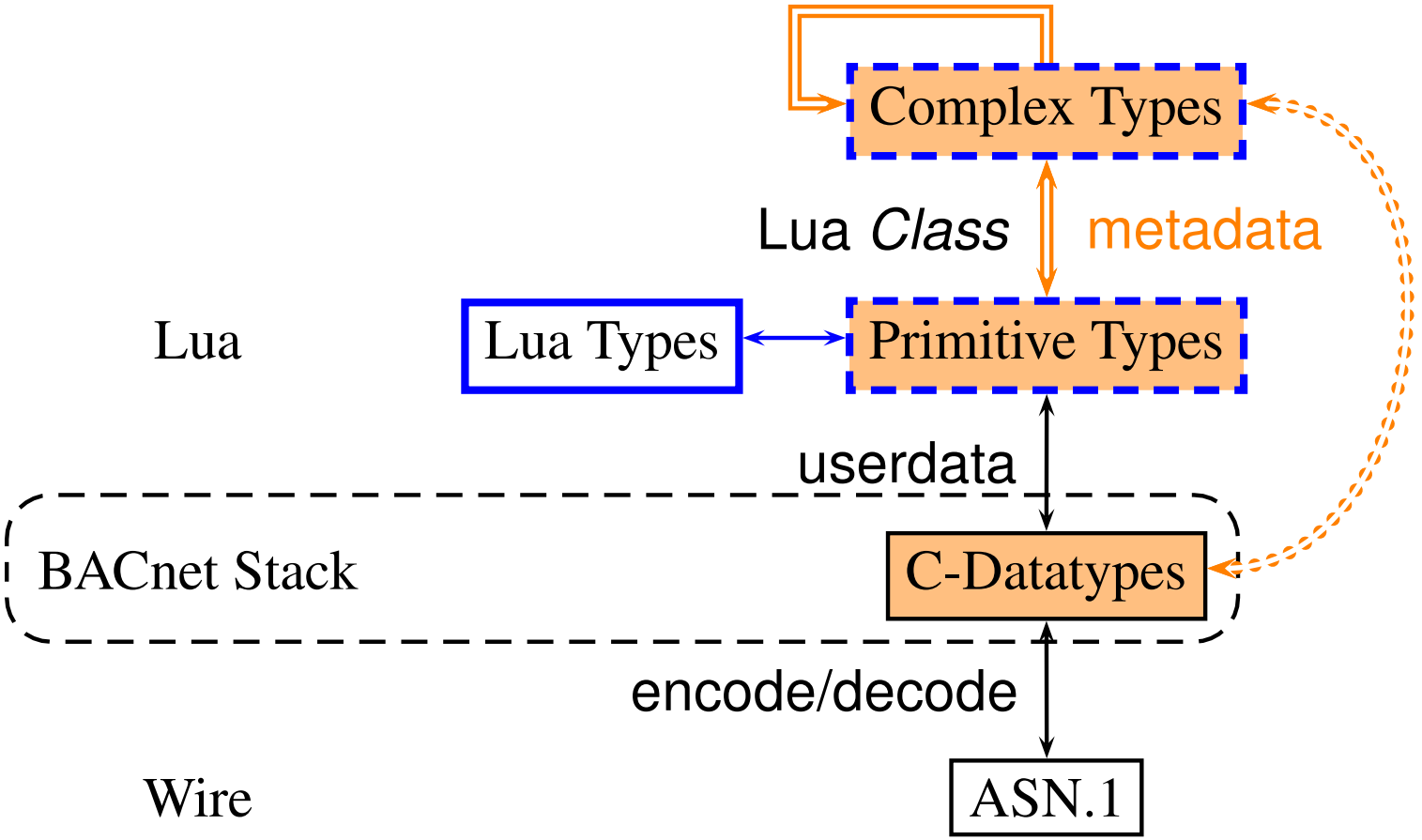
Libs

- Baselibs
- LuaSocket
- LuaFileSystem

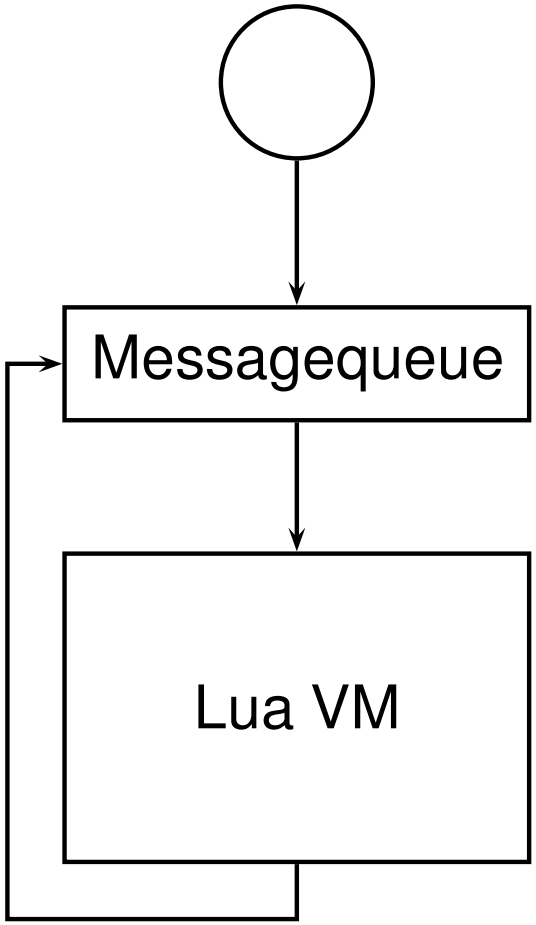
APIs

- Data Points
- Timer
- System Configuration
- User Accounts
- GUI
- BACnet

Lua Program Object
Type System



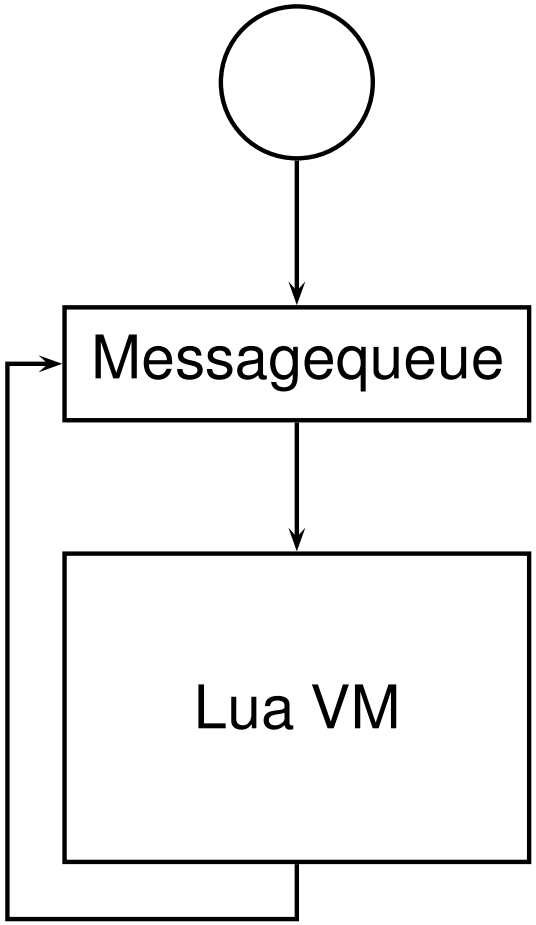
Asynchronous Processing



Callback Functions

- Timers
- System Events
- BACnet COV & BACnet Events
- BACnet Service Responses

Asynchronous Processing



AnalogInput
'coffee level'

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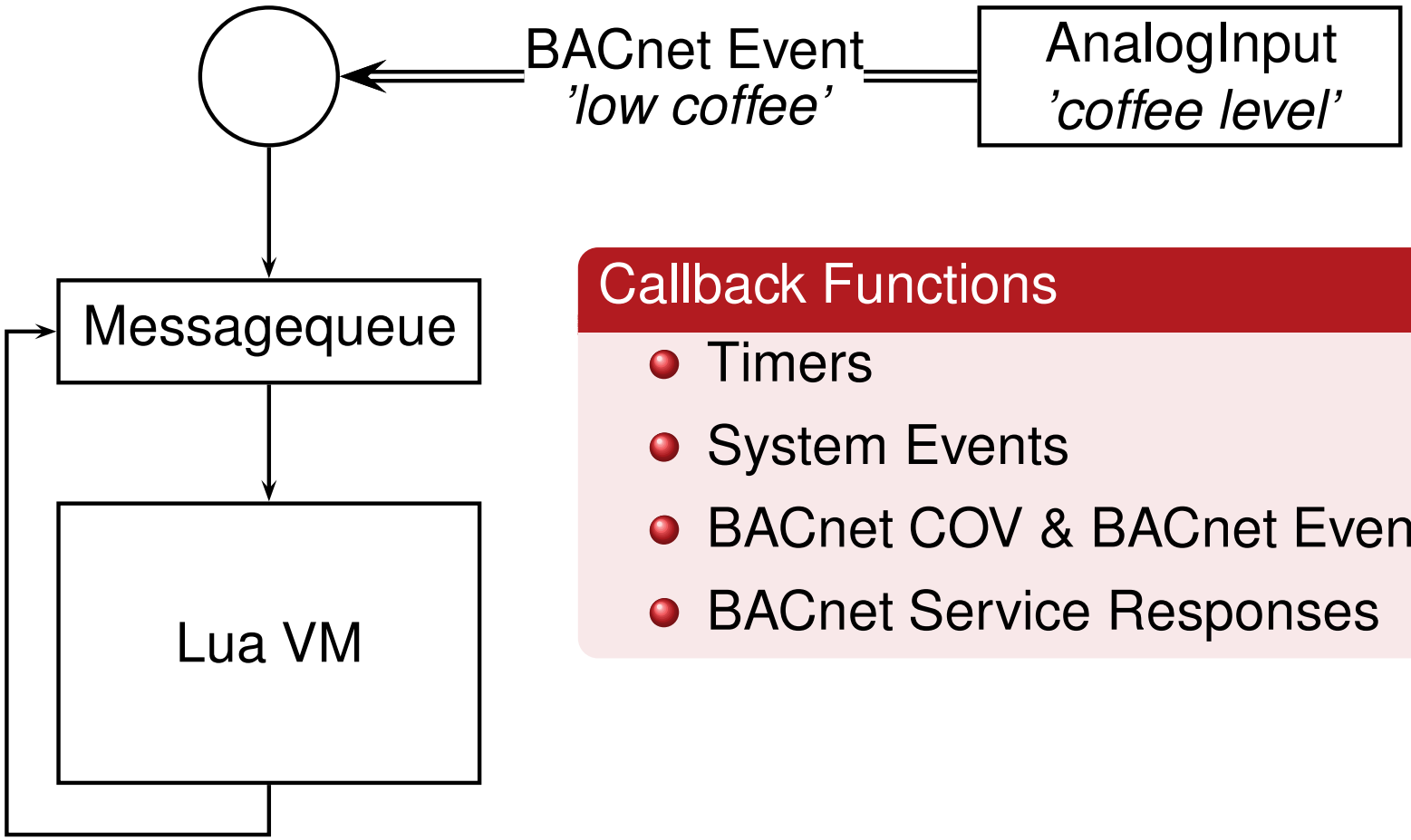

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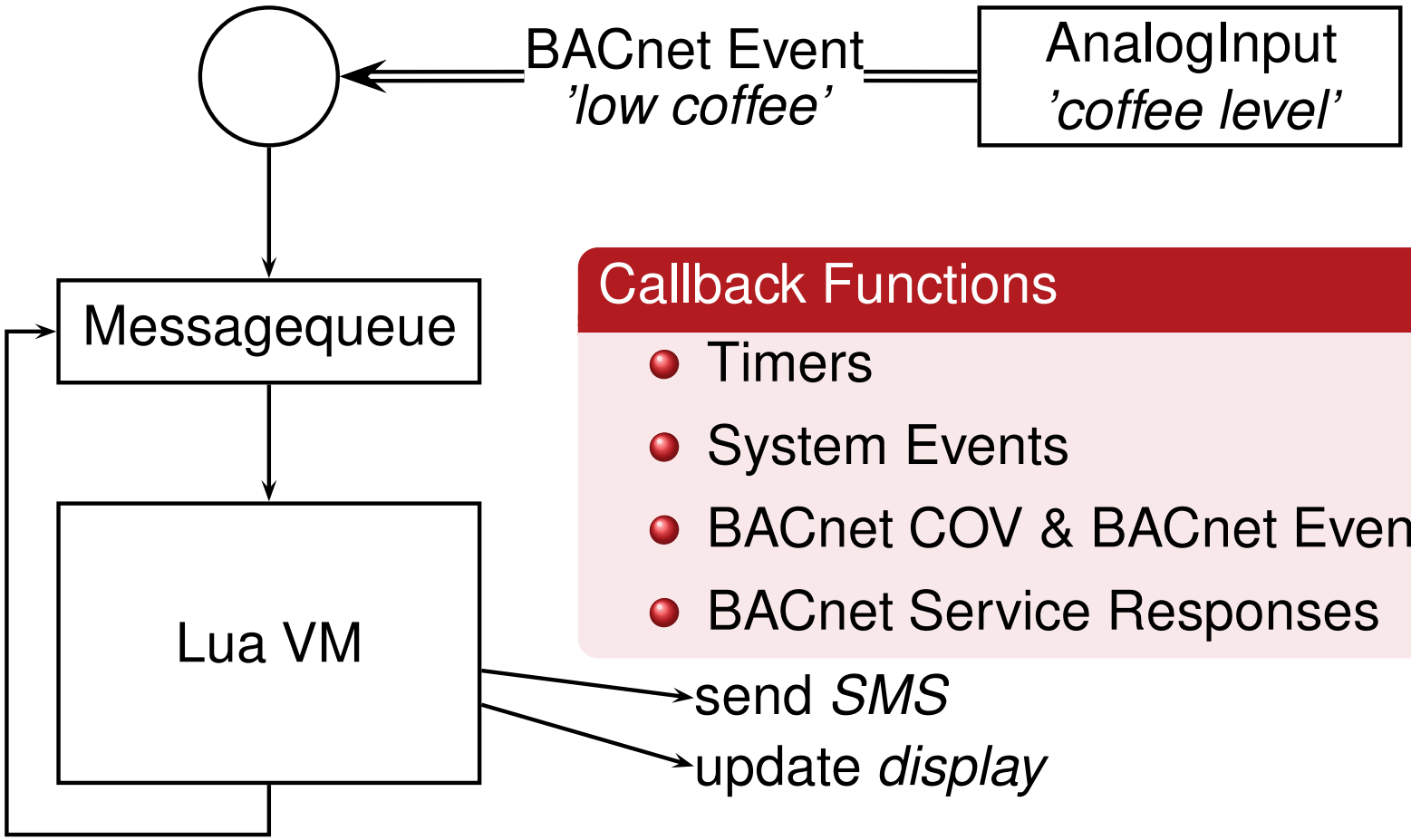

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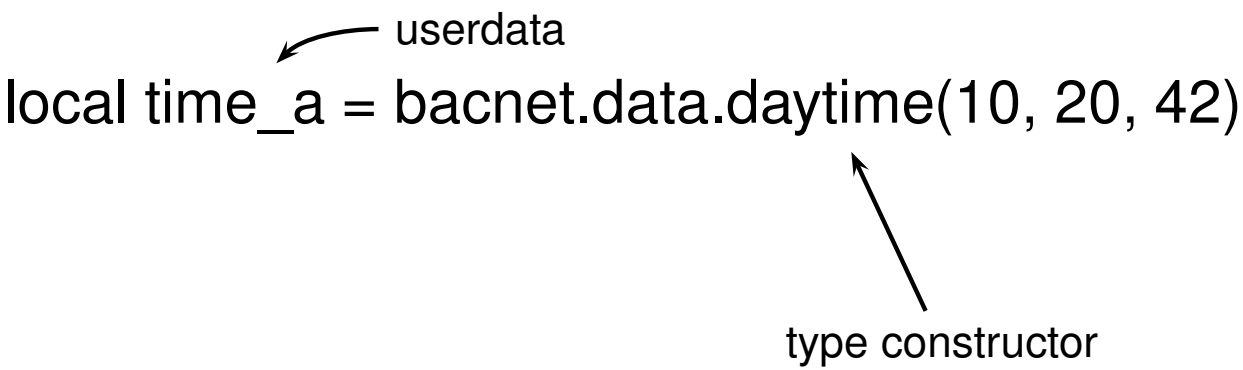
Example
BACnet Datatype Construction in Lua



Example
BACnet Datatype Construction in Lua

```
local time_a = bacnet.data.daytime(10, 20, 42)
local time_b = bacnet.data.daytime("10:19:42")
```

overloaded for convenience

Example
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local time_a = bacnet.data.daytime(10, 20, 42)
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local h,m,s = time_a()
```

convert to Lua type(s)

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local early = time_b < time_a
local datetime = bacnet.data.date_time(
    bacnet.data.daytime("10:41:00"), bacnet.data.date(2013,11,24))
```

complex type is composition of data

time member

date member

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for member, value in pairs(datetime) do
    print(member, value) end
```

again metatable magic

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for member, value in pairs(datetime) do
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local constr_datetime = datetime:typefunc()
```

identical

retrieve constructor from type

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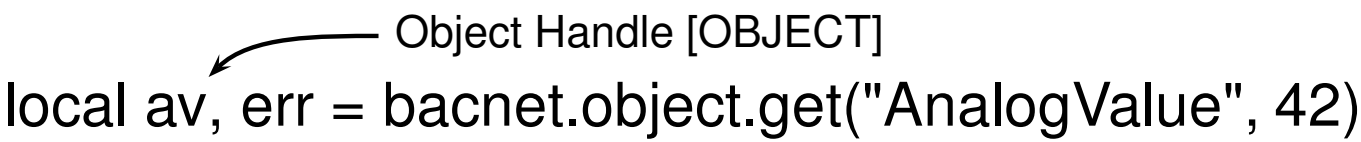
for member, value in pairs(datetime) do
    print(member, value) end
local constr_datetime = datetime:typefunc()
local member_info = constr_datetime()
```

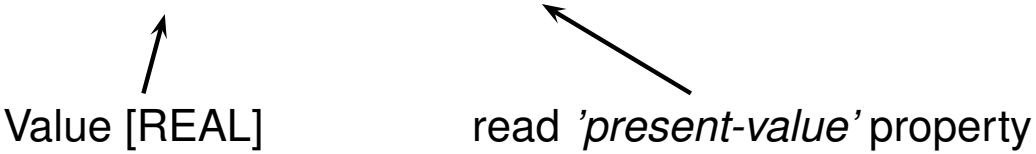
empty call delivers metainfo on members

Example
BACnet Object Access



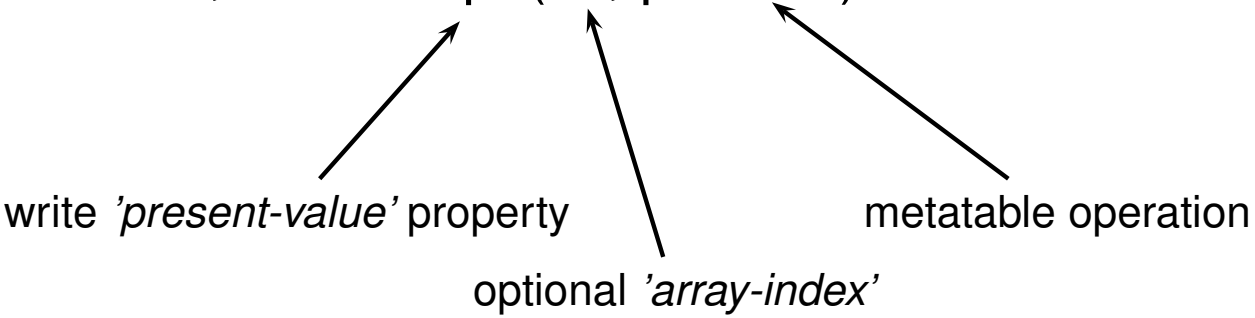
Example
BACnet Object Access

```
local av, err = bacnet.object.get("AnalogValue", 42)
local pv, err = av:pv()
```



Example
BACnet Object Access

```
local av, err = bacnet.object.get("AnalogValue", 42)
local pv, err = av:pv()
local ok, err = av:pv(nil, pv + 12)
```



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```
local av, err = bacnet.object.get("AnalogValue", 42)
local pv, err = av:pv()
local ok, err = av:pv(nil, pv + 12)
local ok, err = av:property(   “low-limit”, nil,
                               bacnet.data.real(15.0))
```

property identifier

read/write arbitrary property

datatype constructor

Example
Timers

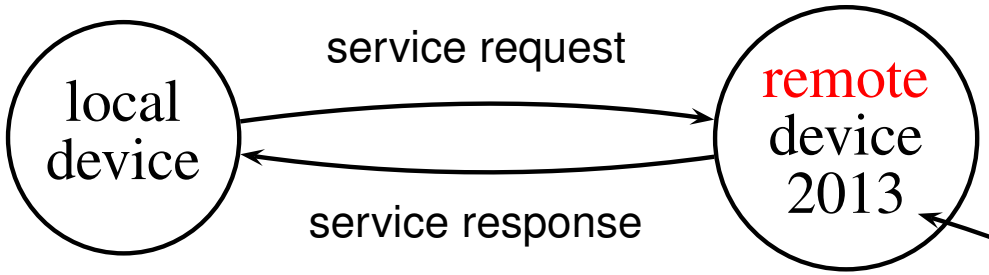
```
Timer = timer.new(function () [...] end)
Timer:start(50)
```

start timer with timeout 50*ms*

timer constructor

callback

Example
BACnet Remote Object Access




```
local ok, err = bacnet.service.write(
    2013,                                    remote device ID
    function (error) [...] end,              response callback (async)
    bacnet.data.objid("AnalogValue", 42),    object ID
    "present-value",                         property ID
    nil,                                     array index
    bacnet.data.real(42))                    write data
```

Application Examples

Display Unit (HMI)

- browse objects
- modify objects
- alarm notifications

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Webserver

- LuaSocket
- e.g. Xavante
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Control Application

- control algorithm in Lua
- based on BACnet objects
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One-Time-Tasks

- initial startup operations
- diagnosis
- maintenance tasks

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Summary
Benefits

- Easy access to BACnet objects and properties.
- Versatile high-level API for customized BACnet applications.
- Possibility for rapid development, rapid deployment and easy in-target debugging of applications.
- No Firmware extension in C needed for OEM applications.

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