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VOLTTRON™ ENERGYPLUS™ AGENT

For Co-Simulation and Control Validation

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VOLTTRON™ 2016

Co-Simulation for Building Controls Development and Validation

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VOLTTRON™ EnergyPlus™ Agent

- Federates message exchange between VOLTTRON™ applications and EnergyPlus™
- Enables “hardware in the loop” testing of algorithms before deploying to buildings
  - Rapid prototype of algorithms
  - Validate
  - Build confidence
  - Test range of operating conditions

VOLTTRON™
Devices | Data | Decisions

EnergyPlus™

- Whole building energy simulation program
- Residential to large commercial
- Energy systems can be controlled through BCVTB interface

EnergyPlus

VOLTTRON™ ←→ EnergyPlus™ Communication Flow

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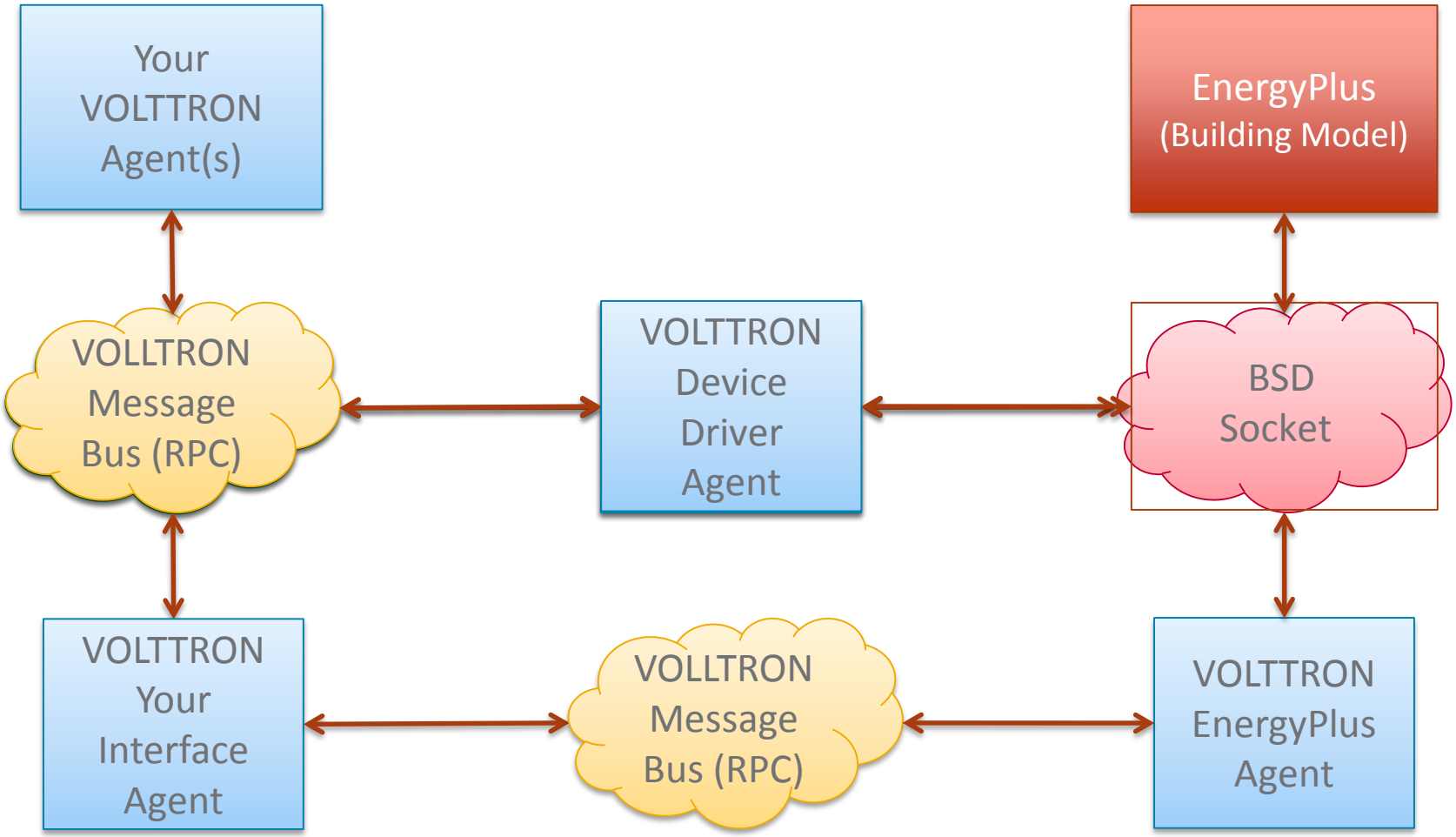

Multiple Input Interfaces for Application Flexibility

- PubSub Interface
  - Useful for quick and dirty development and testing
  - When you need additional abstraction between “building” and application
  - **NOT** the same as the old Actuator pubsub method
- Actuator (RPC) Interface
  - Looks and behaves like an actuator
  - No schedule checking

```
def subscribe(self):
    for key, obj in self.input().iteritems():
        if obj.has_key('topic'):
            callback = self.onMatchTopic
            topic = obj.get('topic')
            keyCaps = 'onMatch'+key[0].upper()+key[1:]
            if obj.has_key('callback'):
                callbackstr = obj.get('callback')
                if (hasattr(self, callbackstr) and
                        callable(getattr(self, callbackstr, None))):
                    callback = getattr(self, callbackstr)
            elif (hasattr(self, keyCaps) and
                        callable(getattr(self, keyCaps, None))):
                callback = getattr(self, keyCaps)
            log.info('subscribed to ' + topic)
            self.vip.pubsub.subscribe(peer='pubsub', prefix=topic, callback=callback)
```

```
@RPC.export
def request_new_schedule(self, requester_id, task_id, priority, requests):

@RPC.export
def request_cancel_schedule(self, requester_id, task_id):

@RPC.export
def get_point(self, topic, **kwargs):

@RPC.export
def set_point(self, requester_id, topic, value, **kwargs):

@RPC.export
def revert_point(self, requester_id, topic, **kwargs):

@RPC.export
def revert_device(self, requester_id, device_name, **kwargs):
```

Mimics Building Automation System Output

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- PubSub Interface
  - Configurable output format
  - Point by point, grouped into topics

```
...
"outputs" : {
    "myVar1" : {
        ...
        "topic" : "pnnl/building/device/weatherstation",
        "field" : "outdoorDryBulbTemperature",
        "meta" : {"units": "C", "tz": "UTC", "type": "float"}
    },
    "myVar2" : {
        ...
        "topic" : "pnnl/building/device/weatherstation",
        "field" : "surfaceIncidentRadiation",
        "meta" : {"units": "W", "tz": "UTC", "type": "float"}
    },
    "myVar3" : {
        ...
        "topic" : "pnnl/building/device/vav/zonetemperature",
        "meta" : {"units": "C", "tz": "UTC", "type": "float"}
    },
    ...
},
...
```

```
[
  {
    'outdoorDryBulbTemperature': 32.0,
    'surfaceIncidentRadiation': 789,
  },
  {
    'outdoorDryBulbTemperature': {"units": "C", "tz": "UTC", "type": "float"},
    'surfaceIncidentRadiation':  {"units": "W", "tz": "UTC", "type": "float"}
  }
]
```

```
[22.0, {"units": "C", "tz": "UTC", "type": "float"}]
```

Communication with EnergyPlus™ uses BCVTB Interface

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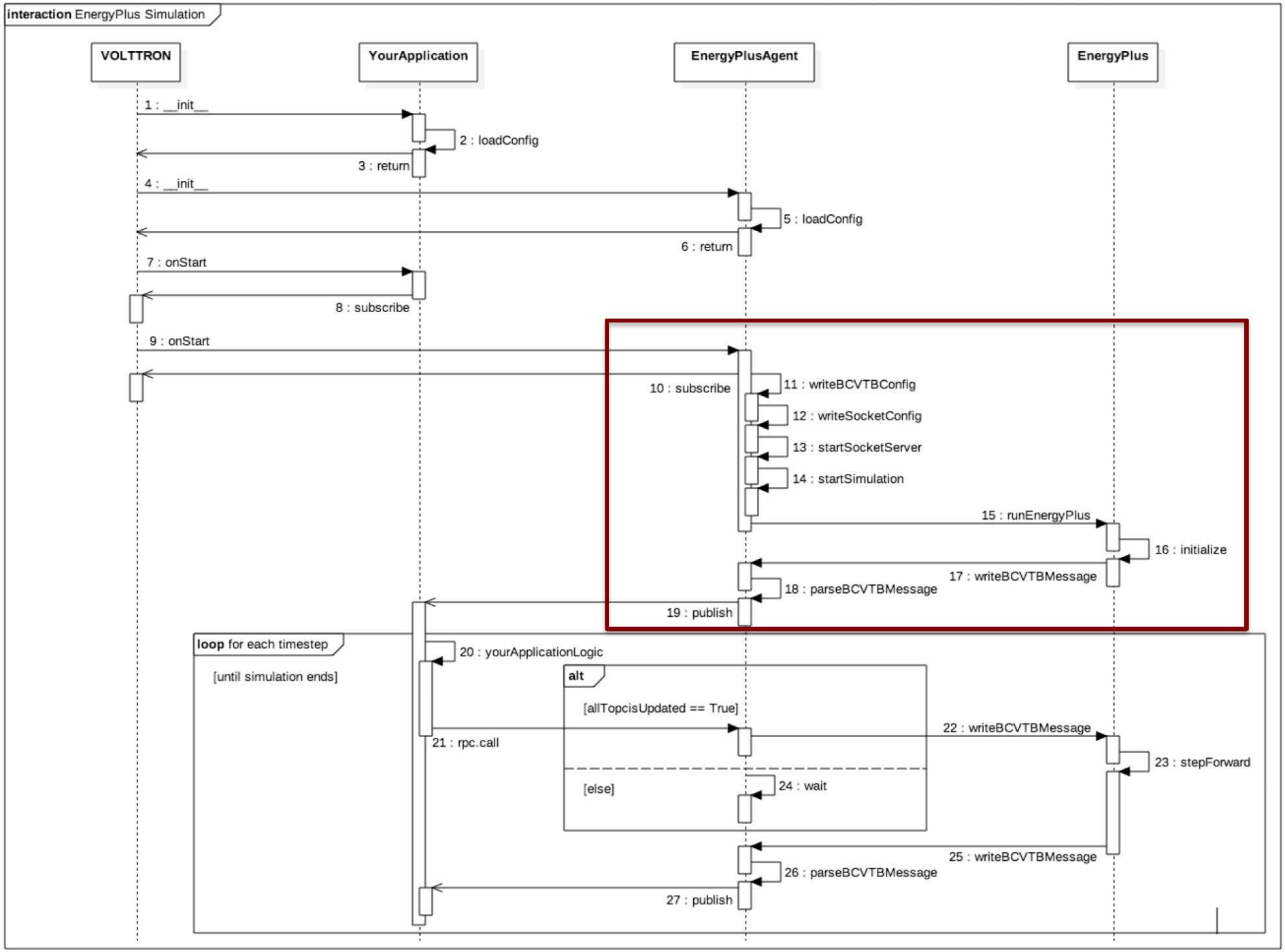
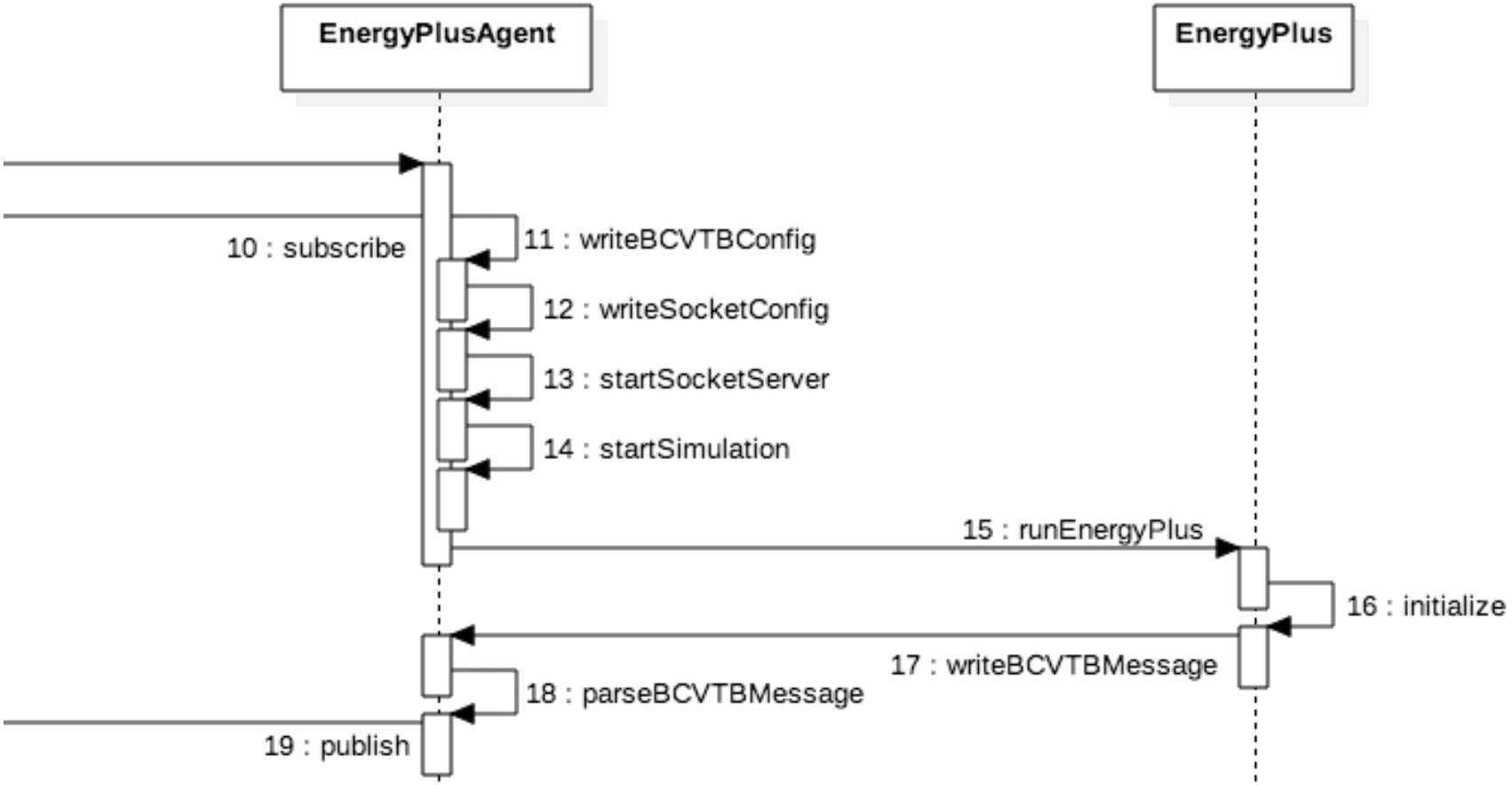
```
{
    "properties" : {
        "identity" : "platform.actuator",
        "model" : "eplus/1ZoneUncontrolled.idf",
        "weather" : "eplus/USA_CO_Golden-NREL.724666_TMY3.epw",
        "bcvtb_home" : "bcvtb"
    },
    "inputs" : {
        "shadeSchedule" : {
            "name" : "WindowShadeSch",
            "type" : "schedule",
            "topic" : "building/windowshades",
            "field" : "schedule"
        },
        "extLightSchedule" : {
            "name" : "ExtLightSch",
            "type" : "schedule",
            "topic" : "building/exteriorlights",
            "field" : "schedule"
        }
    },
    "outputs" : {
        "outdoorDryBulb" : {
            "name" : "ENVIRONMENT",
            "type" : "Site Outdoor Air Drybulb Temperature",
            "topic" : "building/weatherstation",
            "field" : "outdoorDryBulbTemperature",
            "meta" : {"units": "C", "tz": "UTC", "type": "float"}
        },
        "incidentRadiation" : {
            "name" : "Zn001:Wall001:Win001",
            "type" : "Surface Outside Face Incident Solar Radiation Rate per Area",
            "topic" : "building/weatherstation",
            "field" : "surfaceIncidentRadiation",
            "meta" : {"units": "", "tz": "UTC", "type": "float"}
        },
        "horizontalRadiation" : {
            "name" : "ENVIRONMENT",
            "type" : "Site Diffuse Solar Radiation Rate per Area",
            "topic" : "building/weatherstation",
            "field" : "totalHorizontalRadiation",
            "meta" : {"units": "C", "tz": "UTC", "type": "float"}
        }
    }
}
```

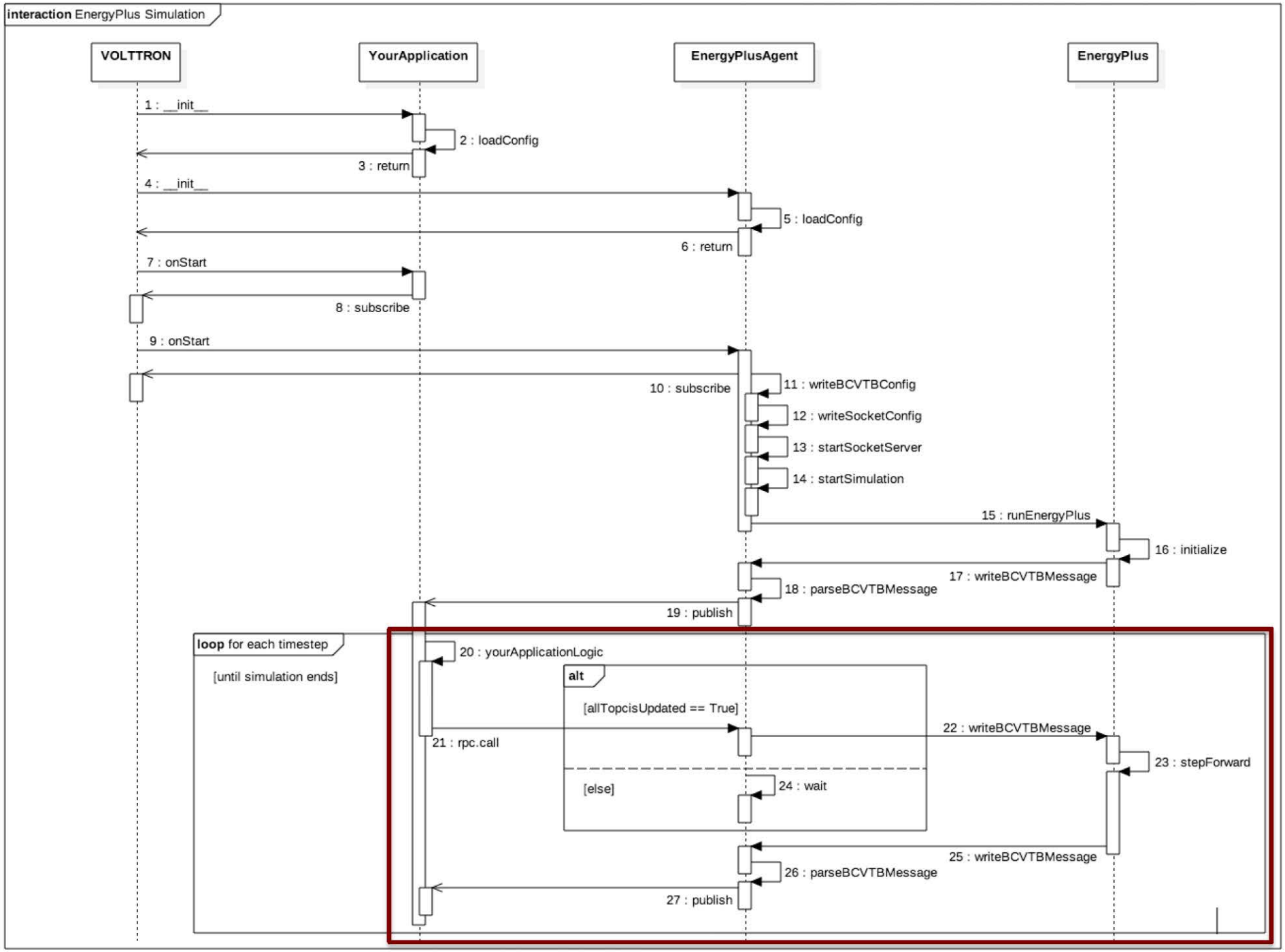
```
WindowProperty:ShadingControl,
  INCIDENT SOLAR ON BLIND, !- Name
  InteriorBlind,           !- Shading Type
  WIN-CON-SINGLEPANE WITH INTERIOR BLIND,  !- Construction with Shading
  OnIfScheduleAllows,      !- Shading Control Type
  WindowShadeSch,          !- Schedule Name
  ,                        !- Setpoint {W/m2, W or deg C}
  YES,                     !- Shading Control Is Scheduled
  NO,                      !- Glare Control Is Active
  ,                        !- Shading Device Material Name
  FixedSlatAngle,          !- Type of Slat Angle Control for Blinds
  ;                        !- Slat Angle Schedule Name

Exterior:Lights,
  ExtLights,               !- Name
  ExtLightSch,             !- Schedule Name
  5250,                    !- Design Level {W}
  AstronomicalClock,       !- Control Option
  Grounds Lights;          !- End-Use Subcategory

ExternalInterface,
  PtolemyServer;

ExternalInterface:Schedule,
  WindowShadeSch,
  On/Off,
  1.0;

ExternalInterface:Schedule,
  ExtLightSch,
  On/Off,
  1.0;

Output:Variable,
  *,
  Site Outdoor Air Drybulb Temperature,timestep;

Output:Variable,
  Zn001:Wall001:Win001,
  Surface Outside Face Incident Solar Radiation Rate per Area,timestep;

Output:Variable,
  *,
  Site Diffuse Solar Radiation Rate per Area,timestep;
```


interaction EnergyPlus Simulation
VOLTTRON
YourApplication
EnergyPlusAgent
EnergyPlus
1 : __init__
2 : loadConfig
3 : return
4 : __init__
5 : loadConfig
6 : return
7 : onStart
8 : subscribe
9 : onStart
10 : subscribe
11 : writeBCVTBConfig
12 : writeSocketConfig
13 : startSocketServer
14 : startSimulation
15 : runEnergyPlus
16 : initialize
17 : writeBCVTBMessage
18 : parseBCVTBMessage
19 : publish
loop for each timestep
[until simulation ends]
20 : yourApplicationLogic
alt
[allTopcisUpdated == True]
21 : rpc.call
22 : writeBCVTBMessage
23 : stepForward
[else]
24 : wait
25 : writeBCVTBMessage
26 : parseBCVTBMessage
27 : publish

BSD Socket Communication with EnergyPlus™

- Agent creates socket server to exchange data with EnergyPlus™

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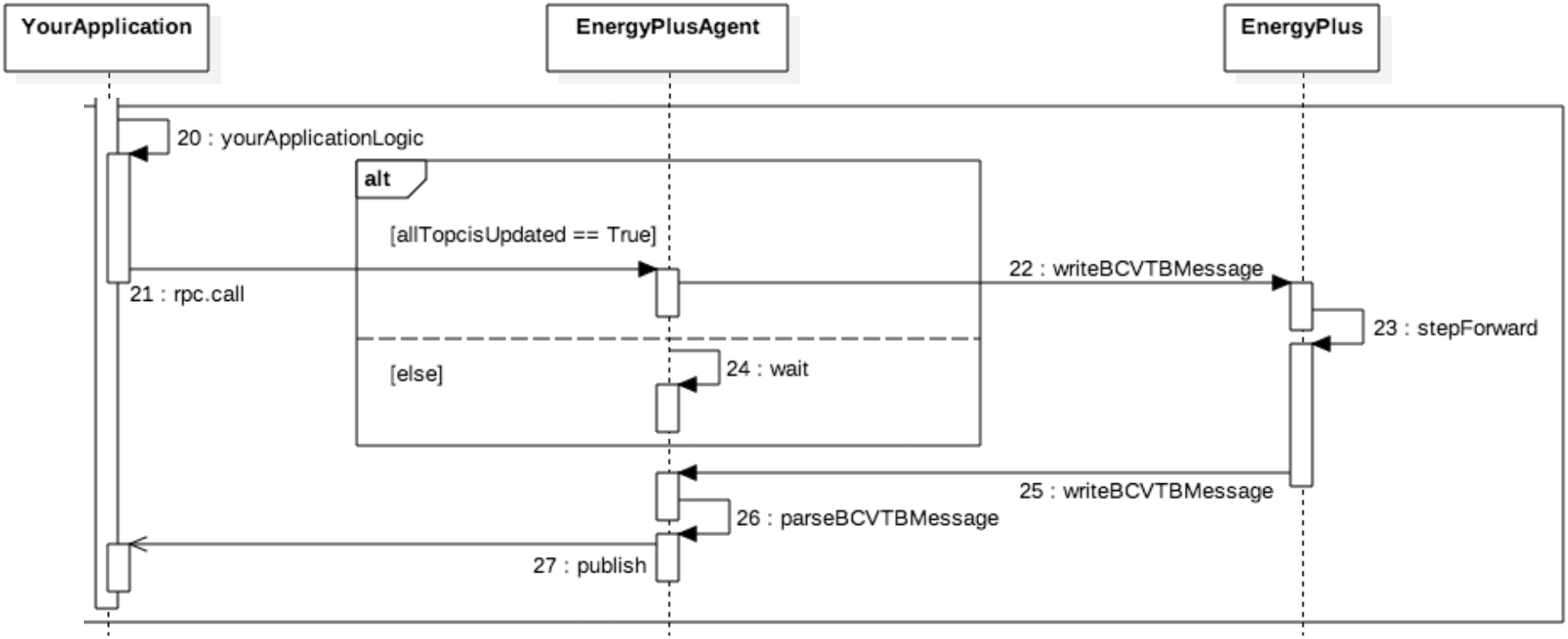
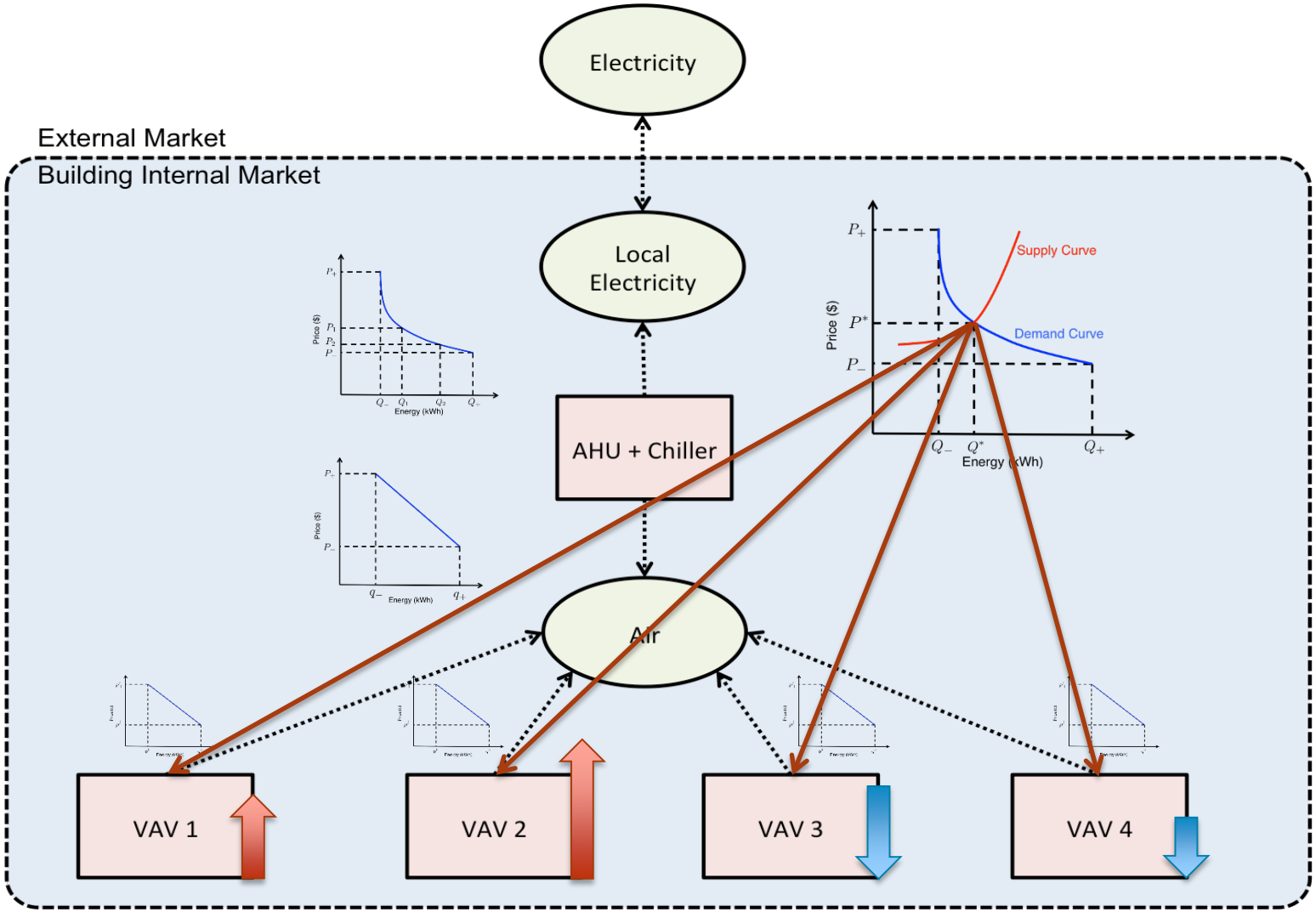
Agent Synchronizes Inputs to EnergyPlus™

- Regardless of input method, agent waits until all ***required*** inputs are updated before sending message to EnergyPlus™



Multi-Agent Transactive Market Structure



Multi-Agent Transactive Market Demo with EnergyPlus™

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