Open Energy System Project
Basis of Hyphae in LF Energy

October 2020
February 2021

OES Project
SDG Group
Sony Computer Science Laboratories, Inc.

Sony CSL

Agenda

1. Who we are
2. What we have achieved
3. Our technologies
4. Next steps

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Research Policy

We conduct researches for the future of humanity apart from existing business area of Sony Group

"**Think extreme, Act beyond boarders**"

Research Areas

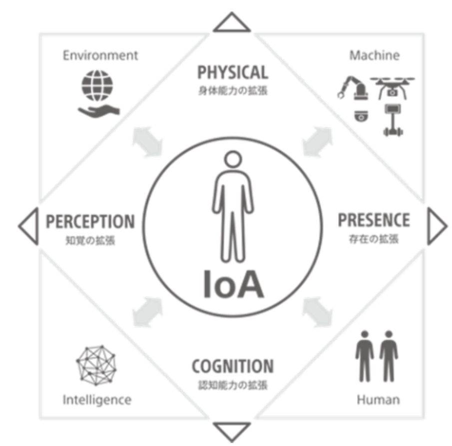
Global Agenda

SDGs – Energy(OES Project), Healthcare, Agriculture, etc.

Cybernetic Intelligence

Data Analysis, AI, etc.

Human Augmentation



Music, Language, Physical, Perception, etc.

OES Project History

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For Sustainable energy society

Off Grid / Weak Grid: Stable energy access

On Grid: Maximize renewable energy

2010

Ghana
Public viewing

2011~2013

Ghana
Off grid system

2014~2020

Okinawa
DCOES platform

2016~2020

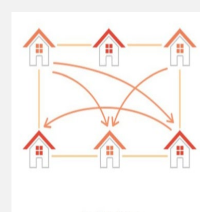
KEIO SFC
DCOES & DC house

Deploy the technology
to realize
Energy Sharing society

Core technologies

- **Storage based solution**
- **Autonomous distributed control**
- **Active current control**

Physical P2P Energy Exchange Platform



Locally produced energy is shared among local users using peer-to-peer distribution mechanism.

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Microgrid in Okinawa

Physical Peer to Peer Energy Exchange Platform

With Okinawa Institute of Science and Technology Graduated University

OIST 沖縄科学技術大学院大学

- System installed to 19 Faculty houses located inside the university
- Behind the mater type of connection to the AC Grid.
- Each house has ether 2.8kW or 4.2kW PV Panels and 4.8kWh batteries.

Operation & Maintenance activities for more than **5** years since 2014 to 2020

Increase **10%** renewable energy up.

System configuration for OIST

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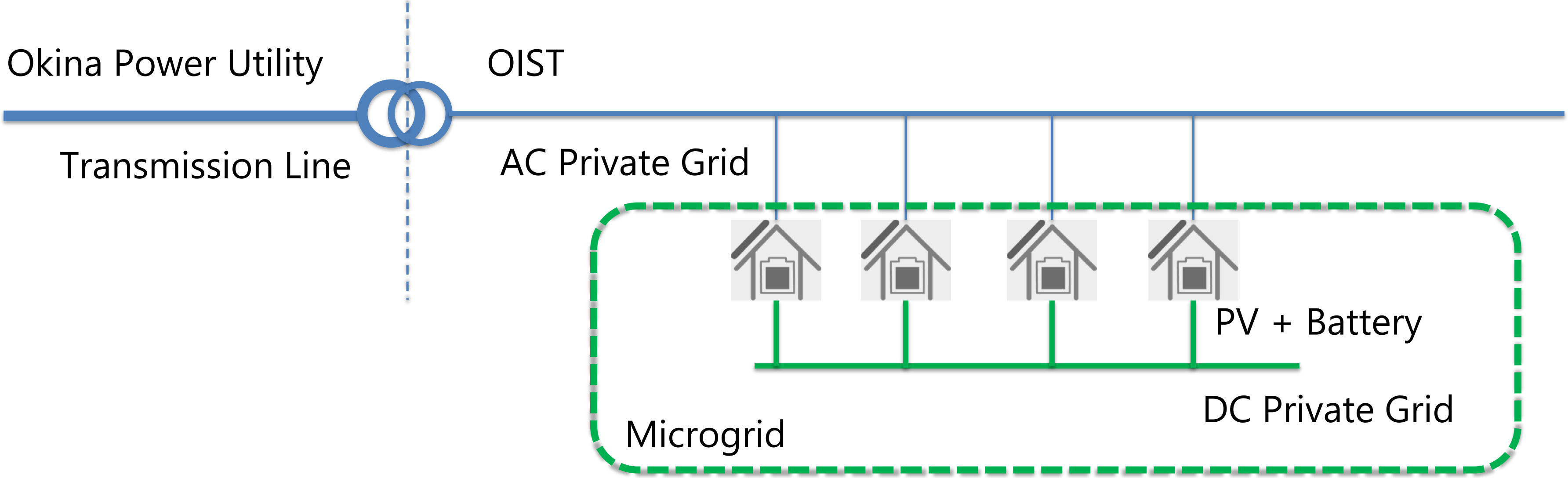

Priority of Energy resource: Solar > Battery > Energy Sharing > AC

No reverse current flow from DC to AC

Effectiveness of energy sharing among batteries

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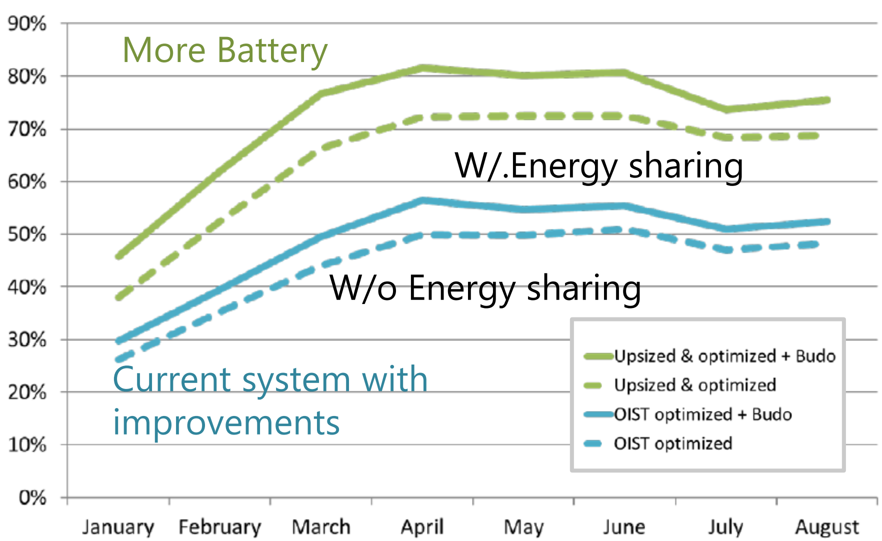
Self-sufficient rate in OIST 2015

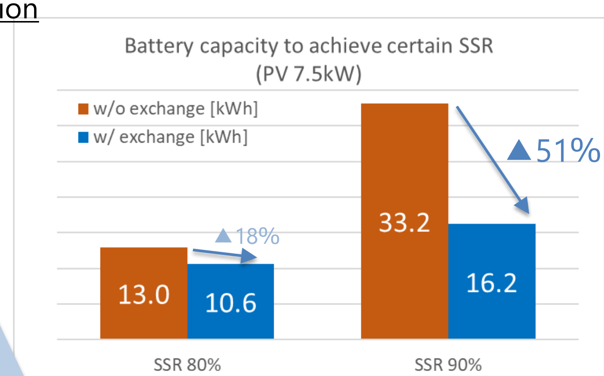
Actual data

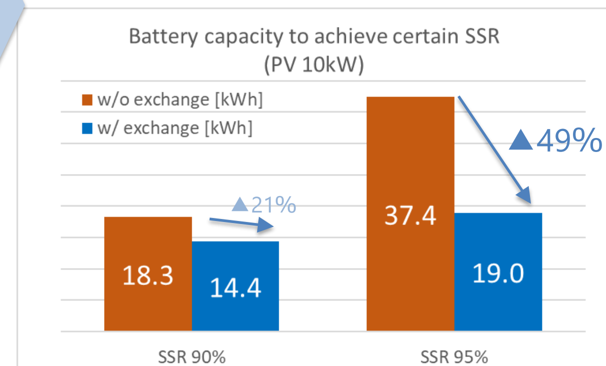


消費はOISTの 2015年の実データより
バッテリー増強: Battery 4.8kWh => 12kWW
改善版 Sharing current 2A=>7A / Change UPS trigger level / Reduce loss

More Self-sufficient rate with more PV

Simulation





Energy sharing with battery cosumes more renewable energy within a community effectivly

Hardware in OIST case

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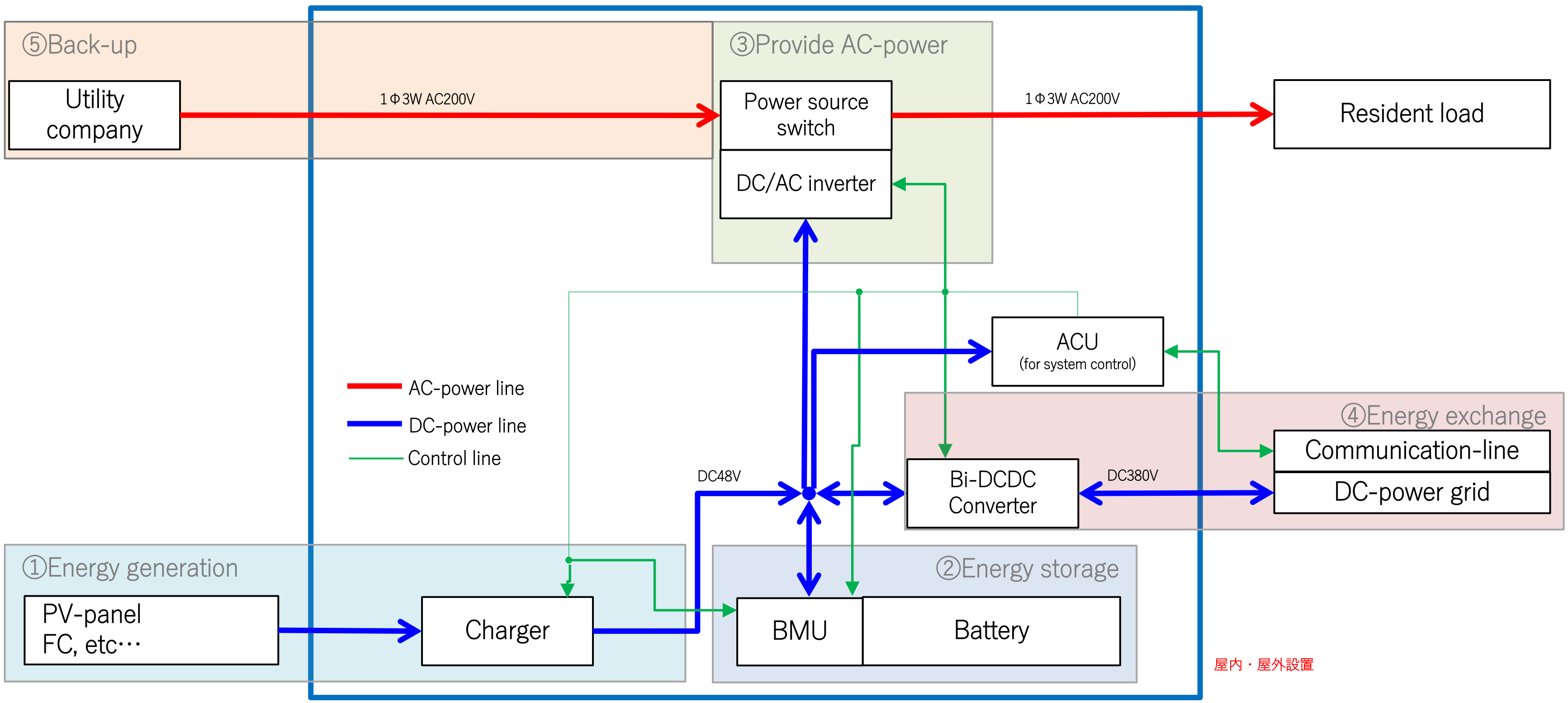
- Battery system for energy exchange
  - ①Energy generation : DC
    - » PV, FC, etc.
  - ②Energy storage : DC
  - ③Energy supply for appliances : DC/AC
  - ④Energy exchange : DC
  - ⑤Backup energy source : (AC)

Share energy among batteries in the community by charge/discharge battery. Reserve backup energy source for the case of lack of battery.

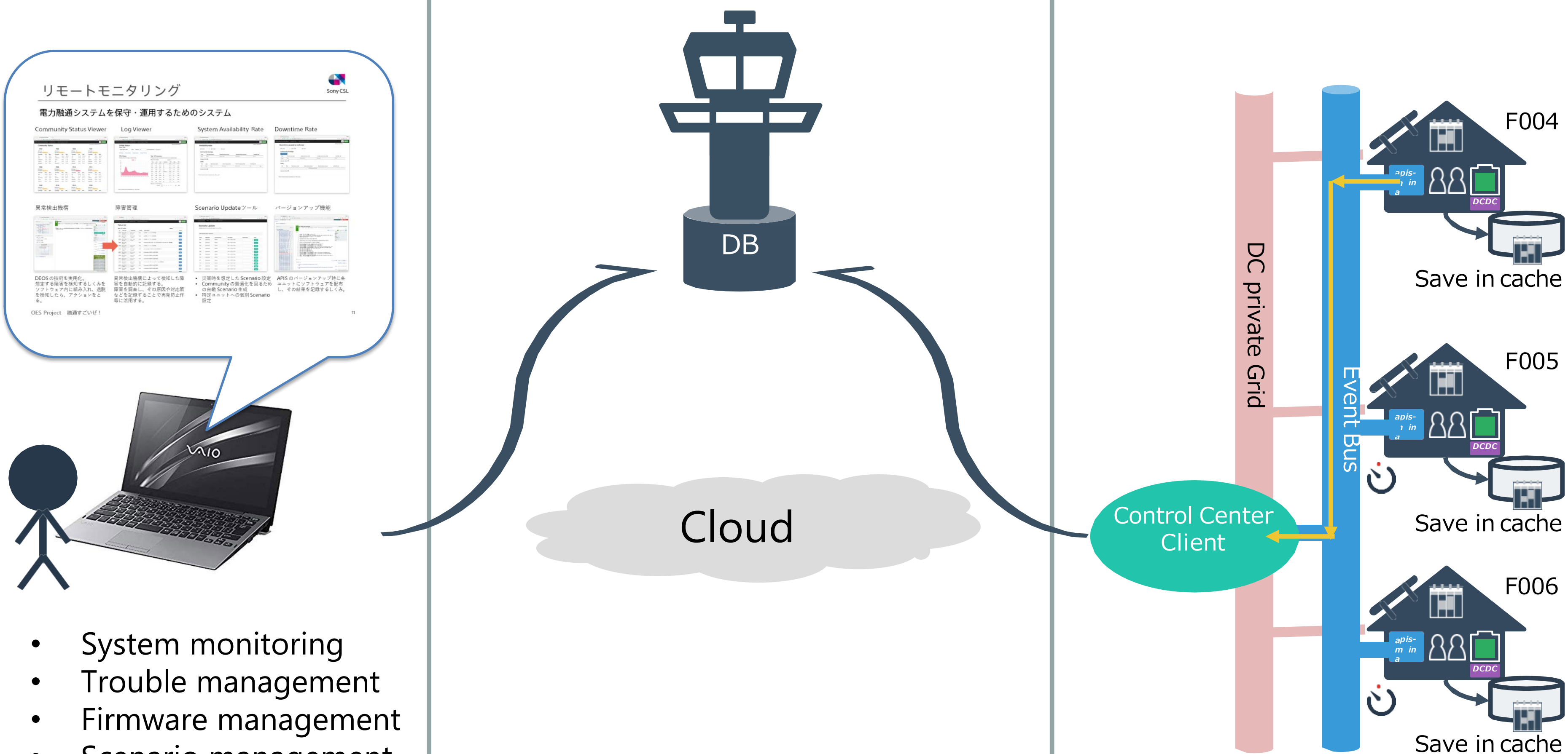


System overview

System administrator

Service Center

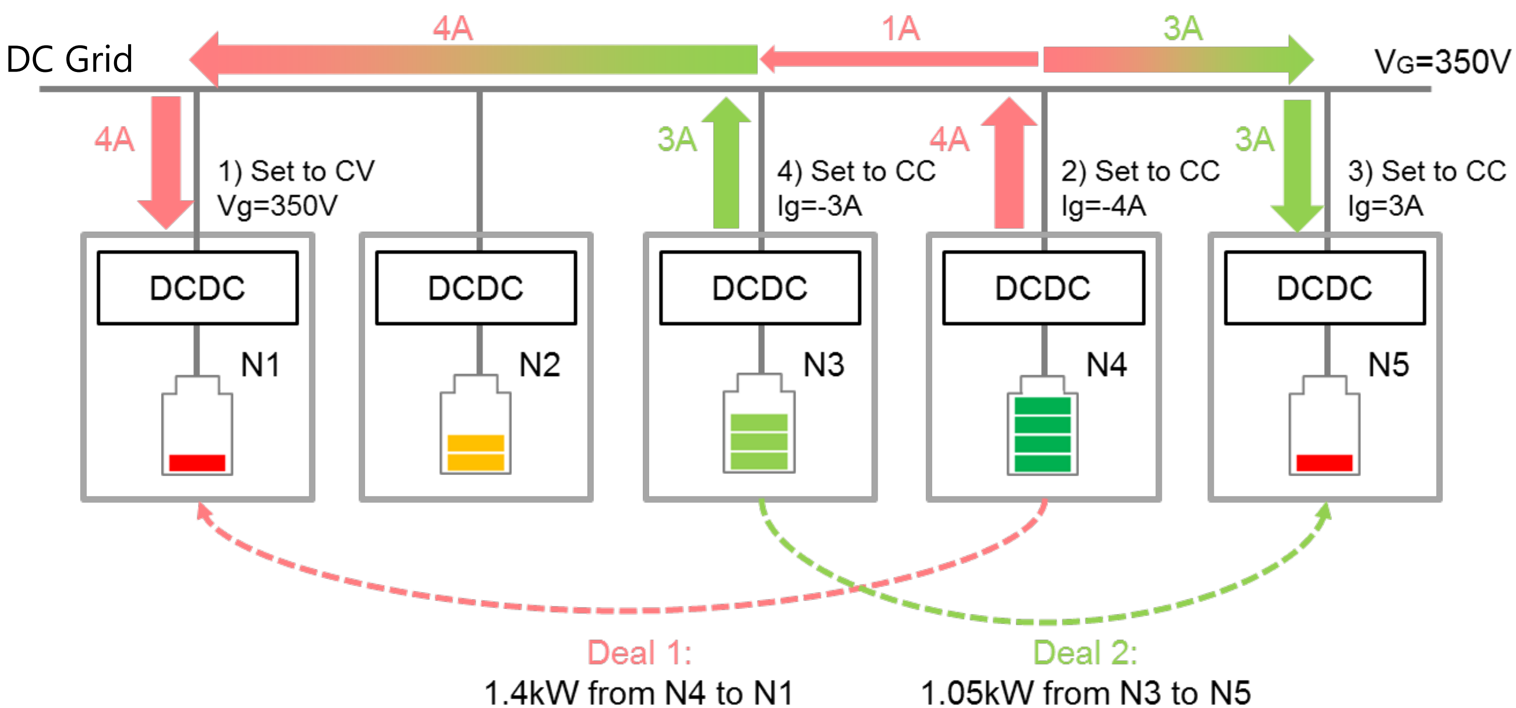
Customer site



- System monitoring
- Trouble management
- Firmware management
- Scenario management

Physical P2P energy exchange

APIS：Autonomous Power Interchange System



Physical P2P ：Energy exchange between certain nodes, certain amount.

CVCC ：Control of power flow without having to worry about physical phenomena caused by location of the houses etc.

DC Bus :DC-DC converters are to be turned-on only during energy exchange in order to minimize the loss.

Autonomous distributed control

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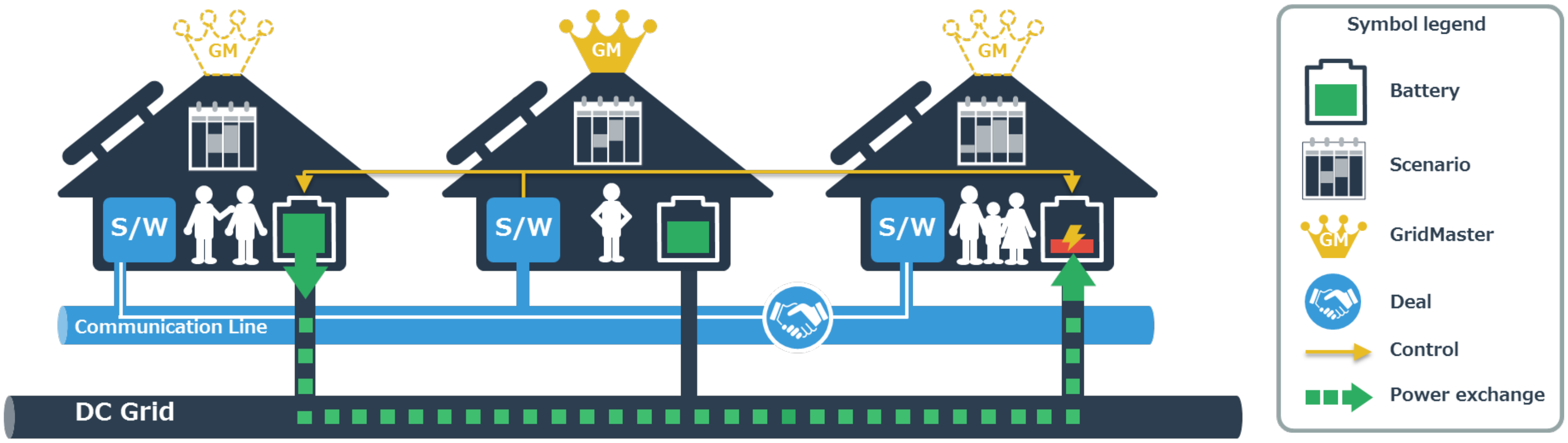
APIS : Autonomous Power Interchange System

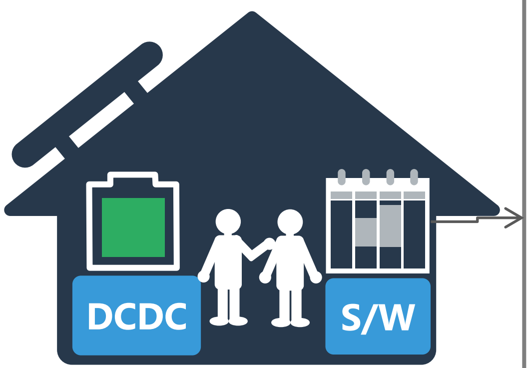


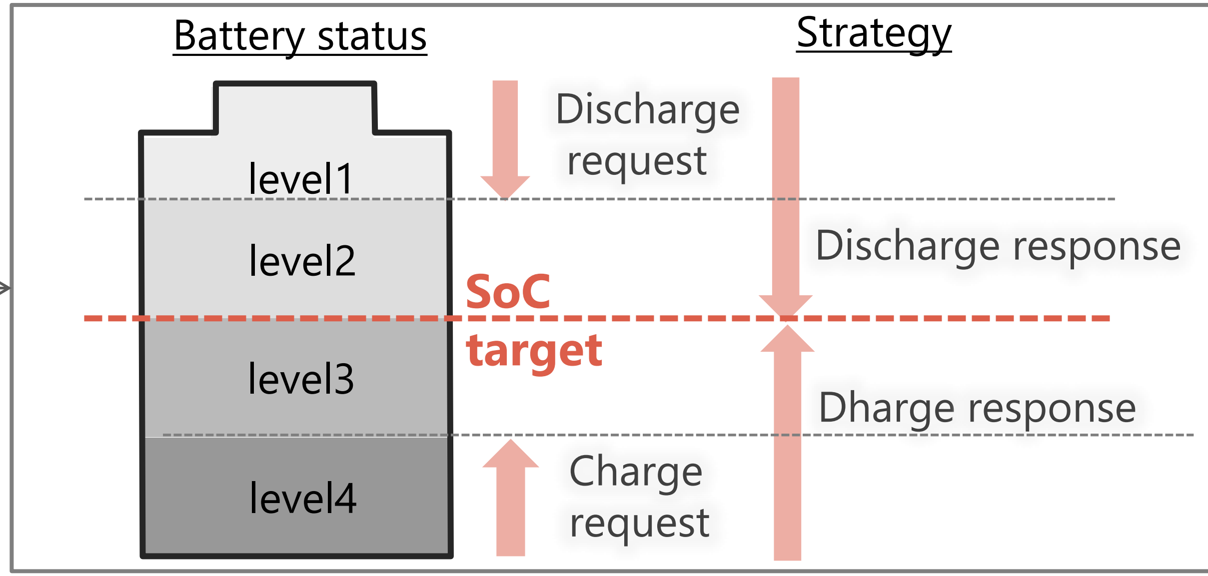
Main points of the APIS

- No central control unit
- Each node has the same software
- Each node check the battery and scenario to determine its action

Energy Exchange Scenario

- State of Charge (SoC) Target energy exchange





	SOC level	Amount	Request: Discharge	Request: Charge	Accept: Discharge	Accept: Charge
level1	90-100	4320-4800	limitWh = 4320	×	limitWh = 3600	×
level2	75-90	3600-4320	×	×		×
level3	60-75	2880-3600	×	×	×	limitWh = 3600
level4	0-60	0-2880	×	limitWh = 2880	×	

8:00-17:00

17:00-20:00

…

scenario.json

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```
"00:00:00-24:00:00" : {
        "batteryStatus" : {
                "4320-"     : "excess",
                "3600-4320" : "sufficient",
                "2880-3600" : "scarce",
                    "-2880" : "short"
        },
```

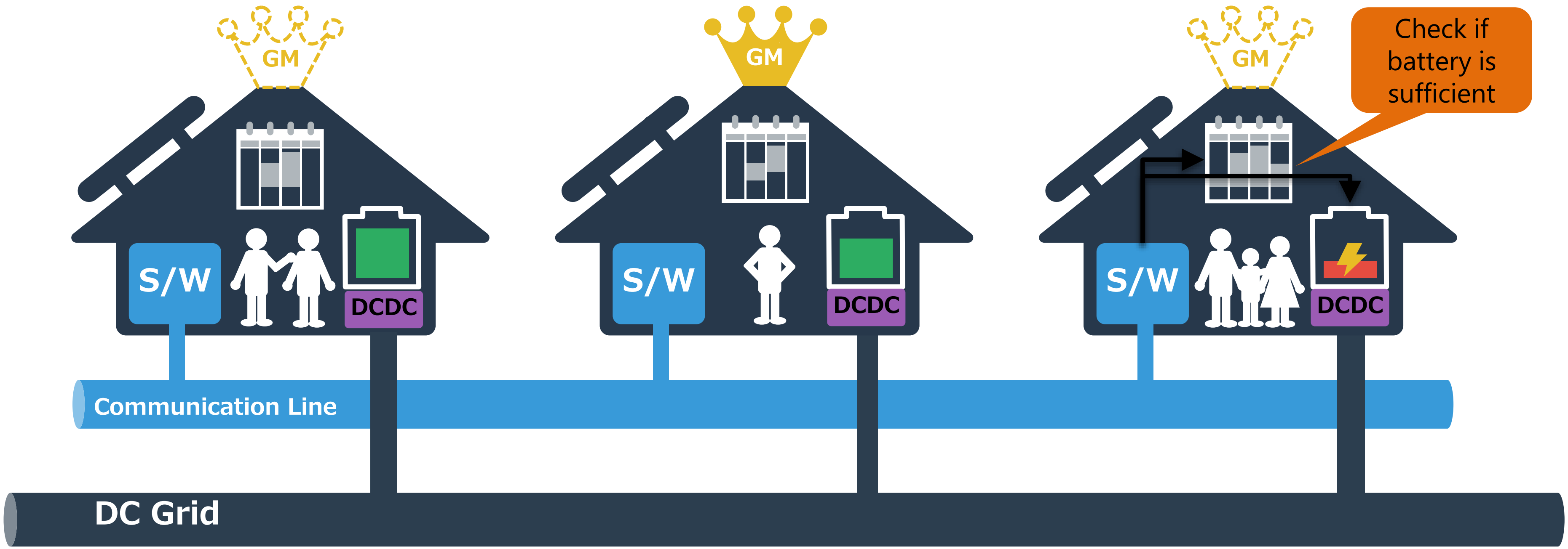
level1,
level2,
level3,
level4

```
                "request" : {
                        "excess" : {
                                "discharge" : {
                                        "limitWh" : 4320,
                                        "pointPerWh" : 10
                                }
                        },
                        "sufficient" : {
                        },
                        "scarce" : {
                        },
                        "short" : {
                                "charge" : {
                                        "limitWh" : 2880,
                                        "pointPerWh" : 10
                                }
                        }
                },
```

```
"accept" : {
        "excess" : {
                "discharge" : {
                        "limitWh" : 3600,
                        "pointPerWh" : 10
                }
        },
        "sufficient" : {
                "discharge" : {
                        "limitWh" : 3600,
                        "pointPerWh" : 10
                }
        },
        "scarce" : {
                "charge" : {
                        "limitWh" : 3600,
                        "pointPerWh" : 10
                }
        },
        "short" : {
                "charge" : {
                        "limitWh" : 3600,
                        "pointPerWh" : 10
                }
        }
}
```

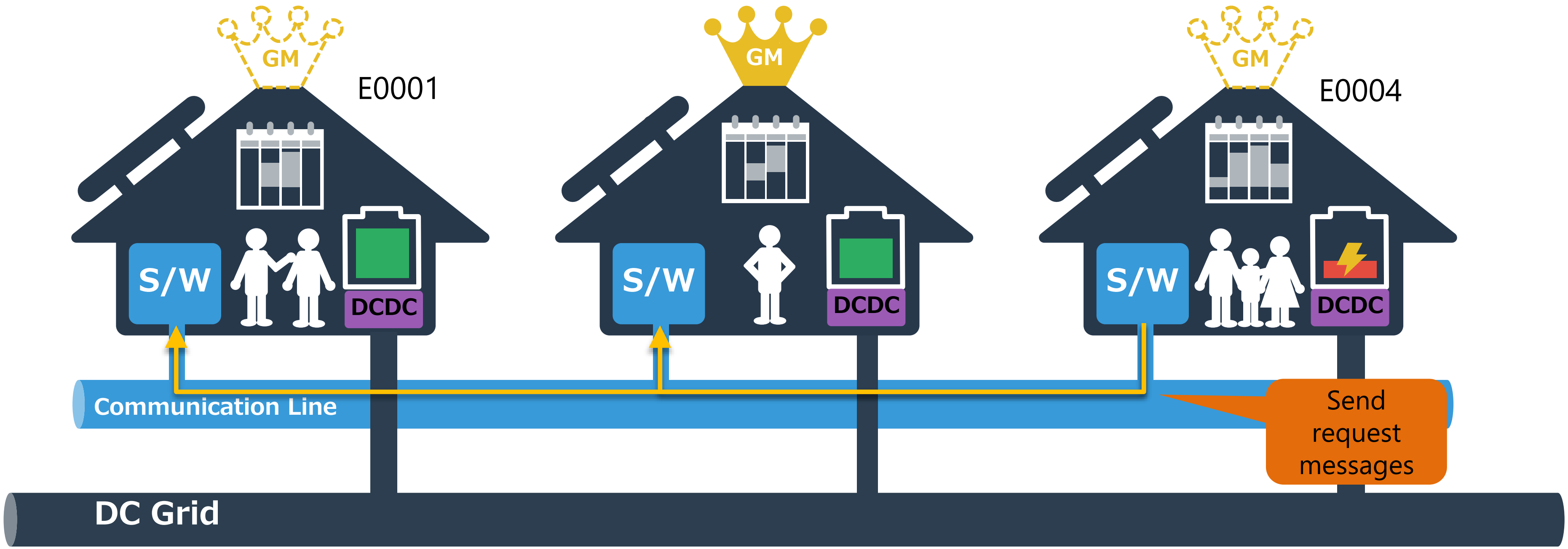
https://github.com/SonyCSL/apis-main/blob/master/exe/scenario.json

Autonomous distributed control (1)



1. The software checks battery level and evaluates scenario (target battery level).

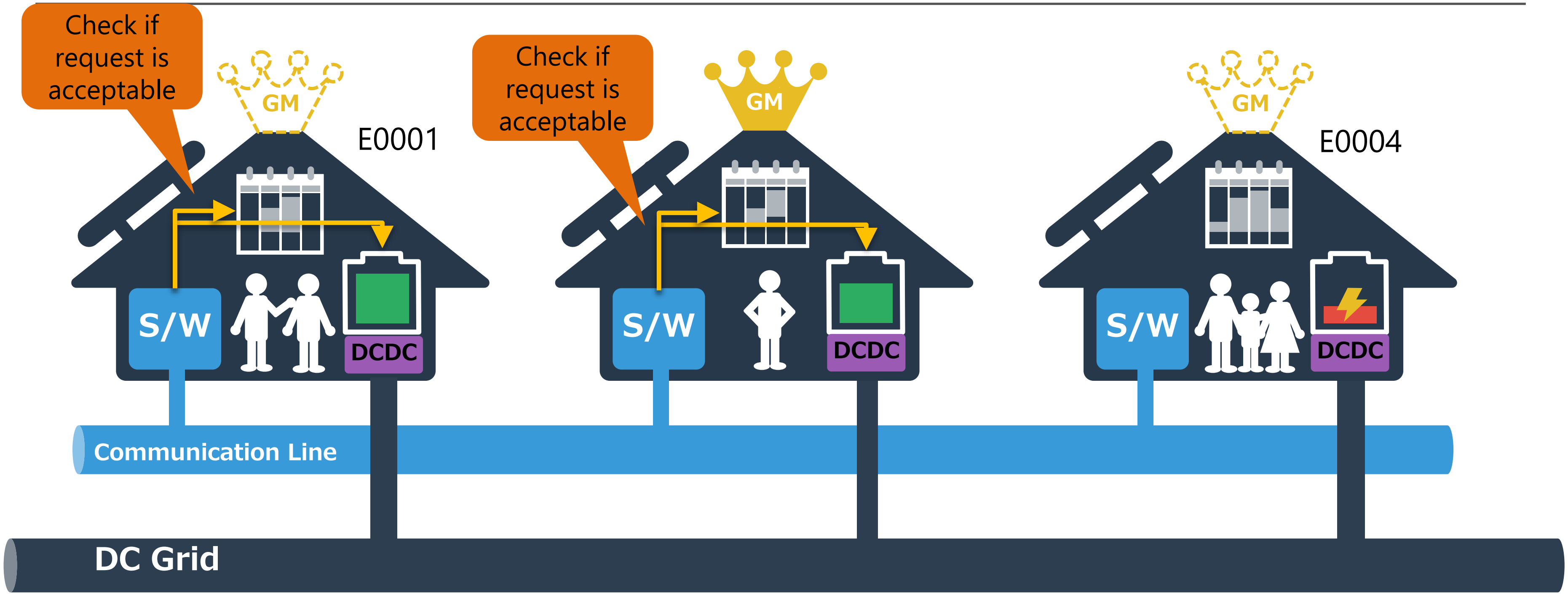
Autonomous distributed control (2)



1. The software checks battery level and evaluates scenario (target battery level).
2. If battery level is lower than scenario, the software sends request messages to other units.

Messages from E0004 to all
request :
{"type":"charge","amountWh":607,"pointPerWh":10.0,"efficientGridVoltageV":312.0,"dateTime":"2020/01/01-00:14:40","dealGridCurrentA":1.0,"unitId":"E004"}

Autonomous distributed control (3)



1. The software checks battery level and evaluates scenario (target battery level).
2. If battery level is lower than scenario, the software sends request messages to other units.
3. If the software receives a request from other unit, it evaluates its own battery level and checks if it can accept the request.

Autonomous distributed control (4)

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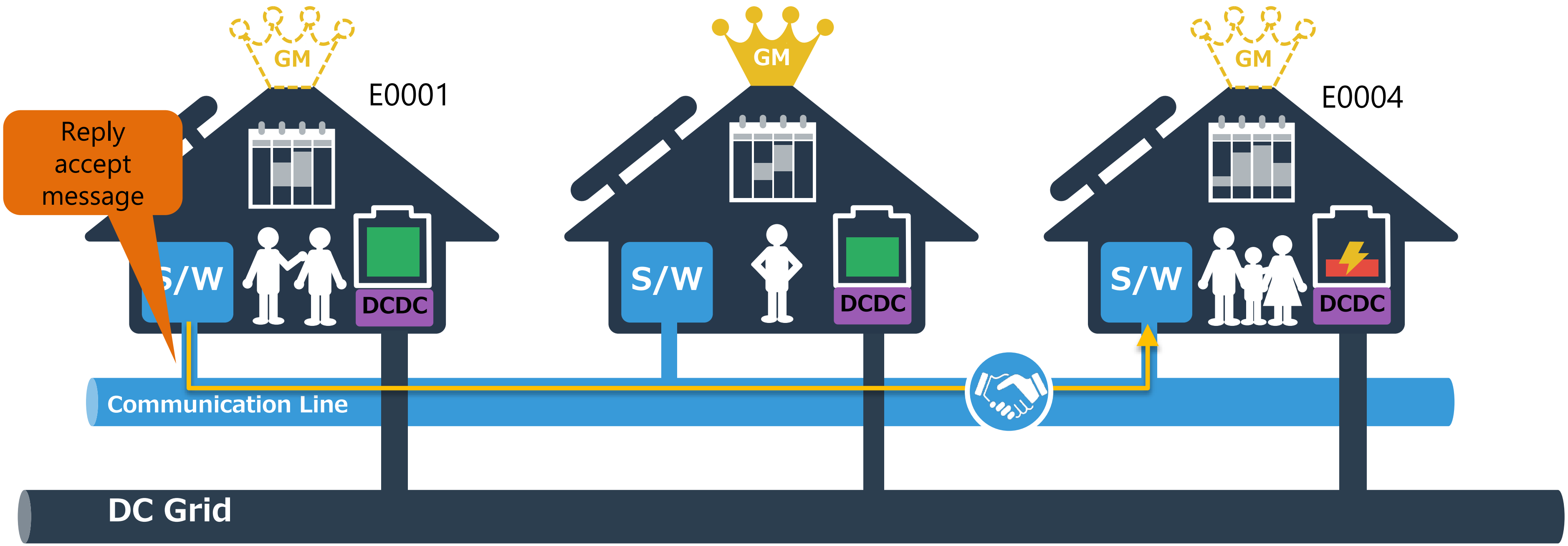

1. The software checks battery level and evaluates scenario (target battery level).
2. If battery level is lower than scenario, the software sends request messages to other units.
3. If the software receives a request from other unit, it evaluates its own battery level and checks if it can accept the request.
4. If the request is acceptable, it replies with an accept message.

Messages from E0001 to E0004
accept :
{"type":"discharge","amountWh":1096,"pointPerWh":10.0,"efficientGridVoltageV":312.0,"dateTime":"2020/01/01-00:14:40","dealGridCurrentA":1.0,"unitId":"E001"}

Autonomous distributed control (5)

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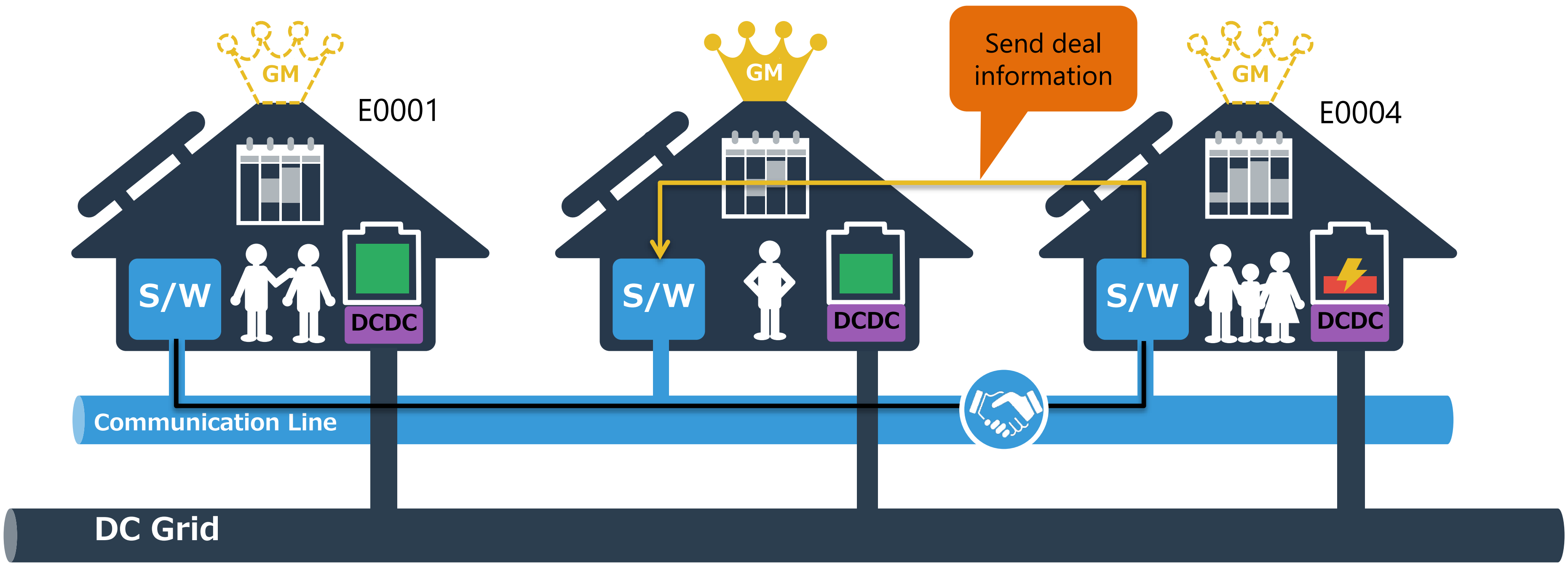

1. The software checks battery level and evaluates scenario (target battery level).
2. If battery level is lower than scenario, the software sends request messages to other units.
3. If the software receives a request from other unit, it evaluates its own battery level and checks if it can accept the request.
4. If the request is acceptable, it replies with an accept message.
5. If requested unit receives an accept message, it sends deal information to Grid Master (GM).

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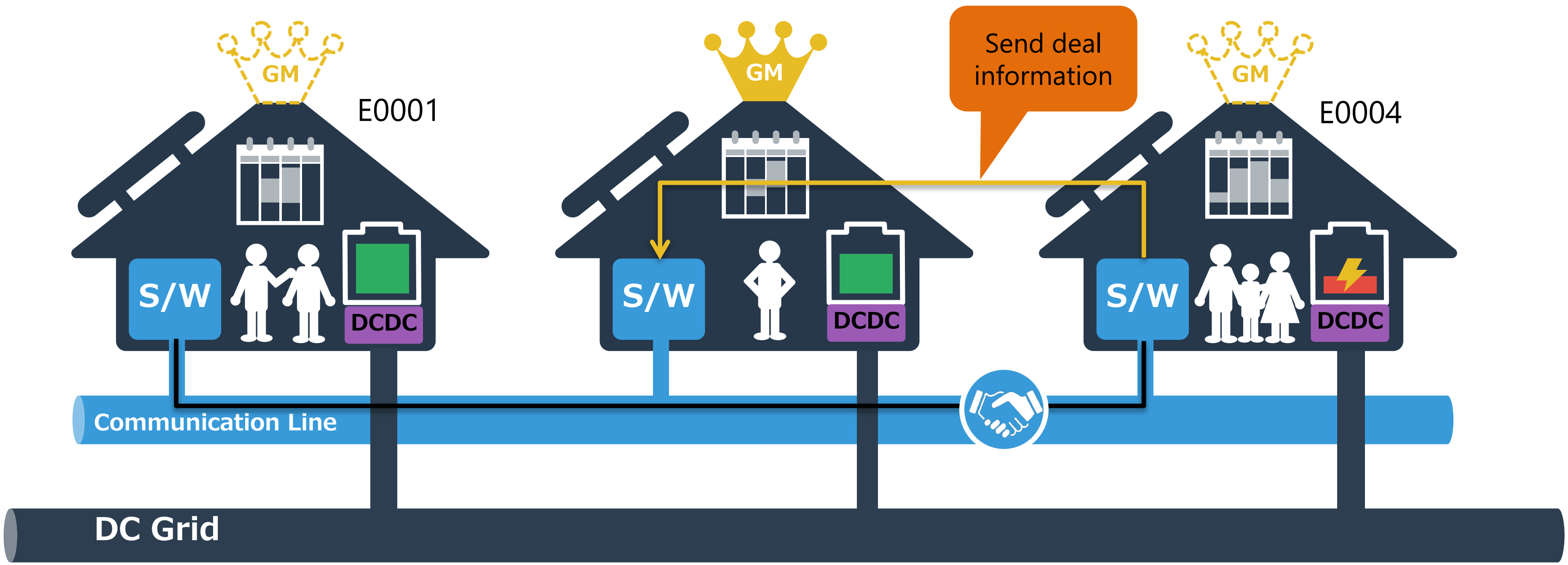
Autonomous distributed control (5)



1. The software checks battery level and evaluates scenario (target battery level).
2. If battery level is lower than scenario, the software sends request messages to other units.
3. If the software receives a request from other unit, it evaluates its own battery level and checks if it can

Messages from E0004 to Grid Master
Deal:

{"unitId":"E004","negotiationId":"9a9b3fd6-dcf0-4673-bdd1-a7c707172f2c","requestUnitId":"E004","acceptUnitId":"E001","requestDateTime":"2020/01/01-00:14:40","acceptDateTime":"2020/01/01-00:14:40","requestPointPerWh":10.0,"acceptPointPerWh":10.0,"requestDealGridCurrentA":1.0,"acceptDealGridCurrentA":1.0,"type":"charge","chargeUnitId":"E004","dischargeUnitId":"E001","pointPerWh":10.0,"chargeUnitEfficientGridVoltageV":312.0,"dischargeUnitEfficientGridVoltageV":312.0,"dealGridCurrentA":1.0,"requestAmountWh":607,"acceptAmountWh":1096,"dealAmountWh":50,"dealId":"ac085f02-73b4-44bf-80ad-6dd5313becef","createDateTime":"2020/01/01-00:15:40","compensationTargetVoltageReferenceGridCurrentA":-1.0,"activateDateTime":"2020/01/01-00:16:00","isMaster":true},

Autonomous distributed control (6)

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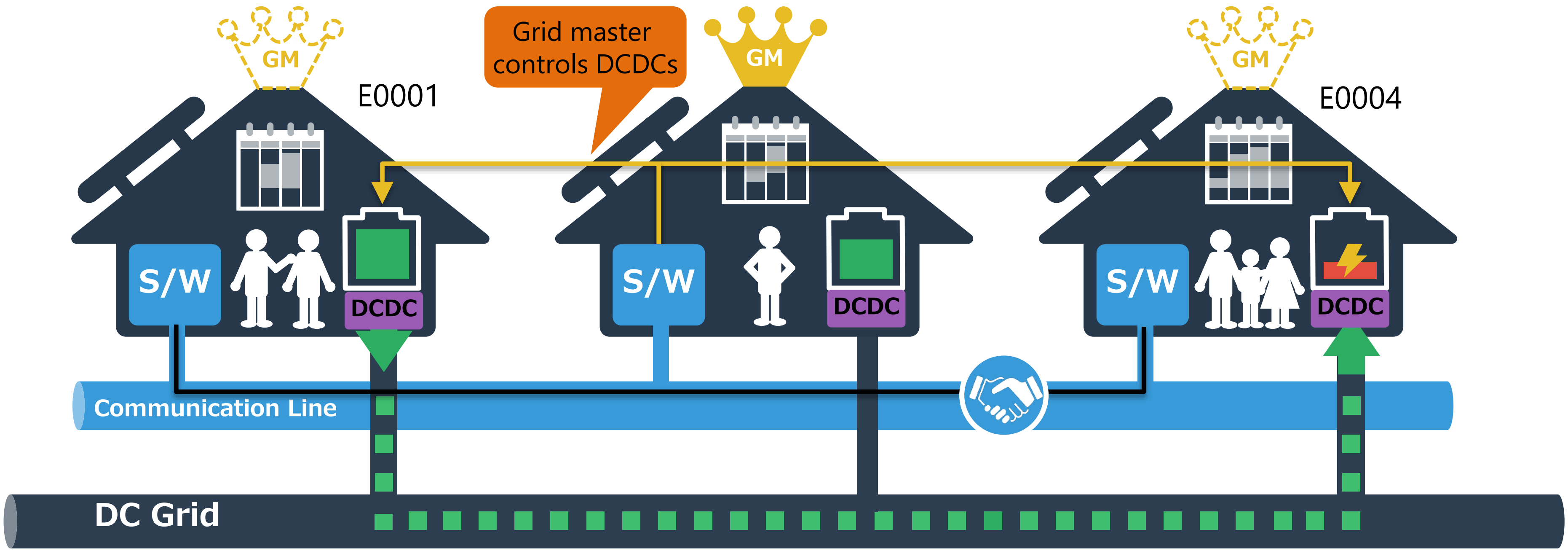

1. The software checks battery level and evaluates scenario (target battery level).
2. If battery level is lower than scenario, the software sends request messages to other units.
3. If the software receives a request from other unit, it evaluates its own battery level and checks if it can accept the request.
4. If the request is acceptable, it replies with an accept message.
5. If requested unit receives an accept message, it sends deal information to Grid Master (GM).
6. GM controls DCDCs to execute energy exchange.

APIS application stack

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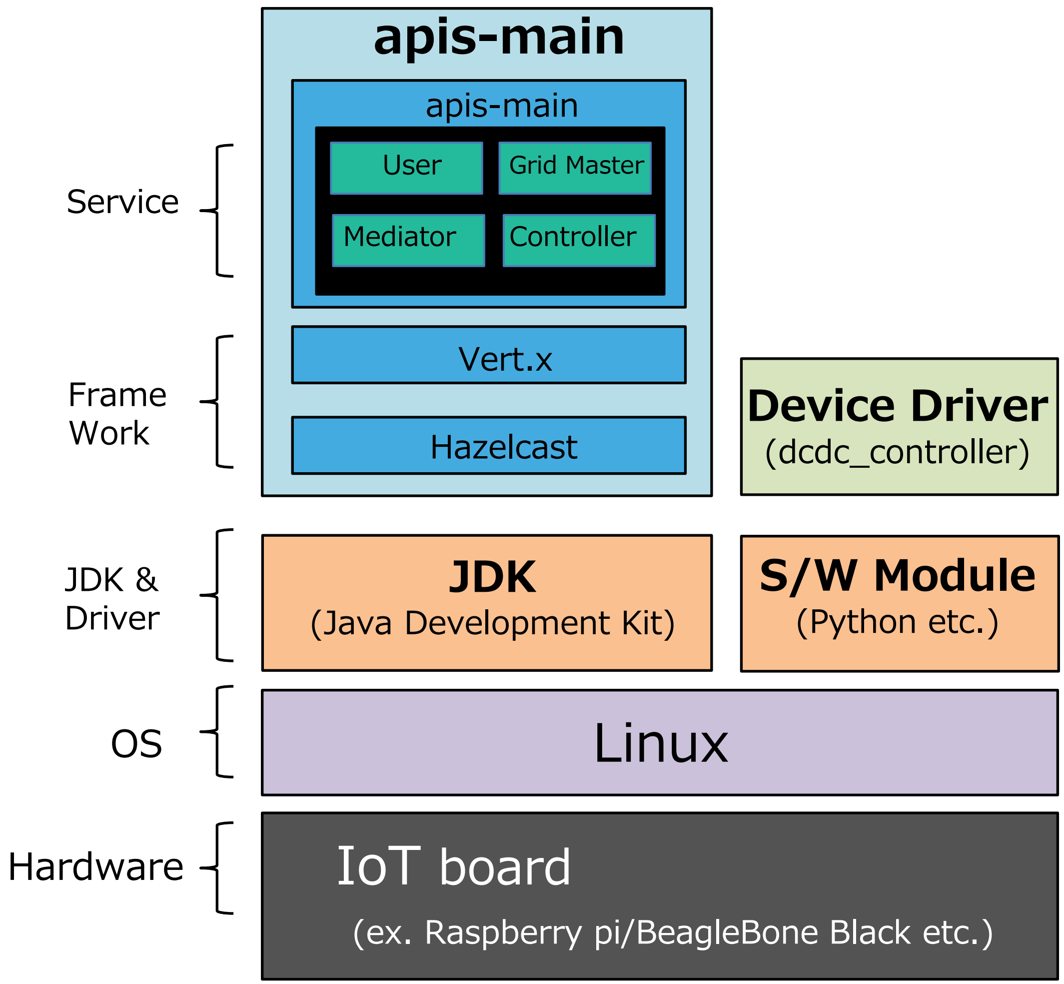
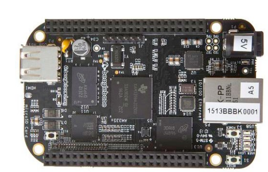
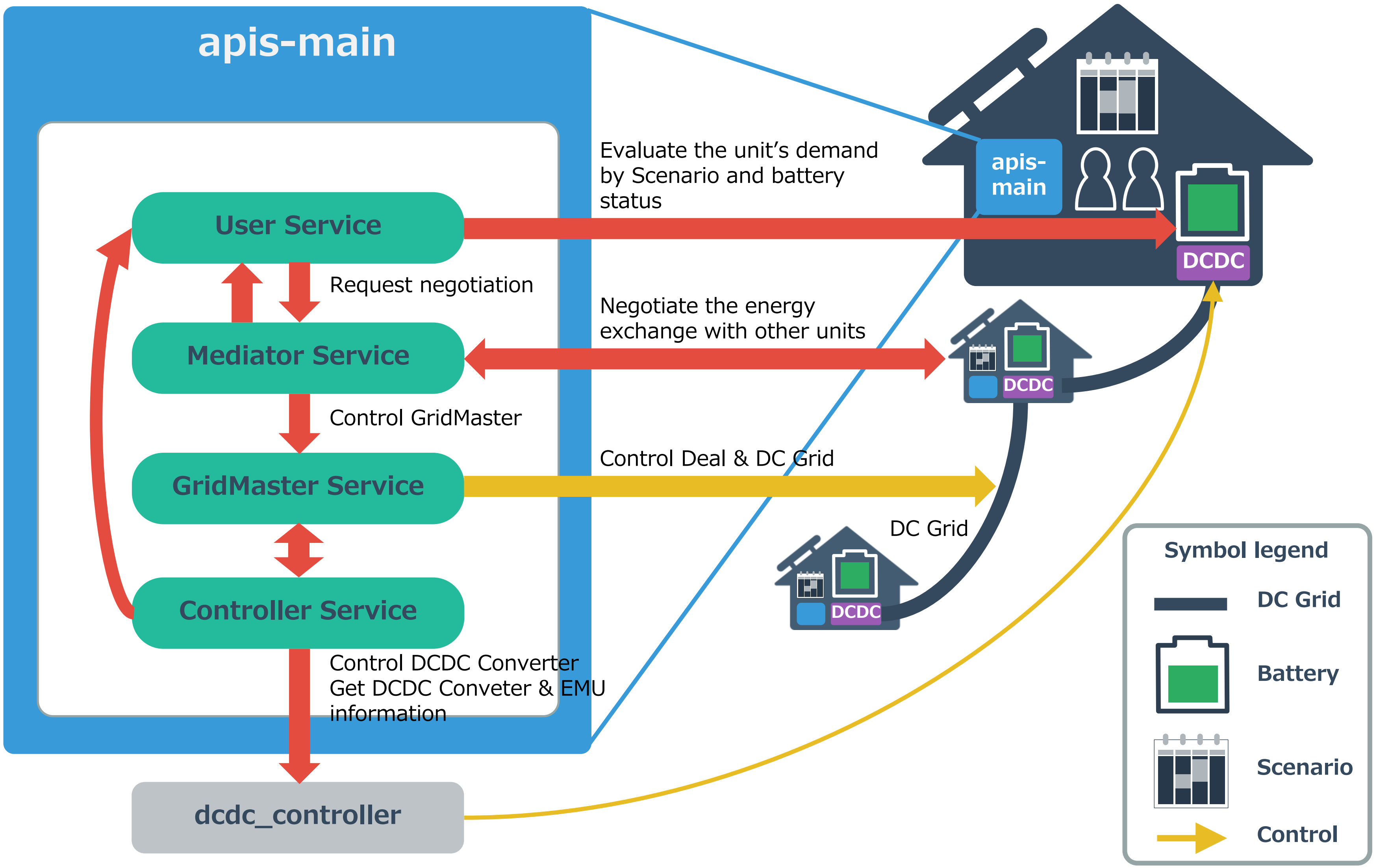
Linux based system



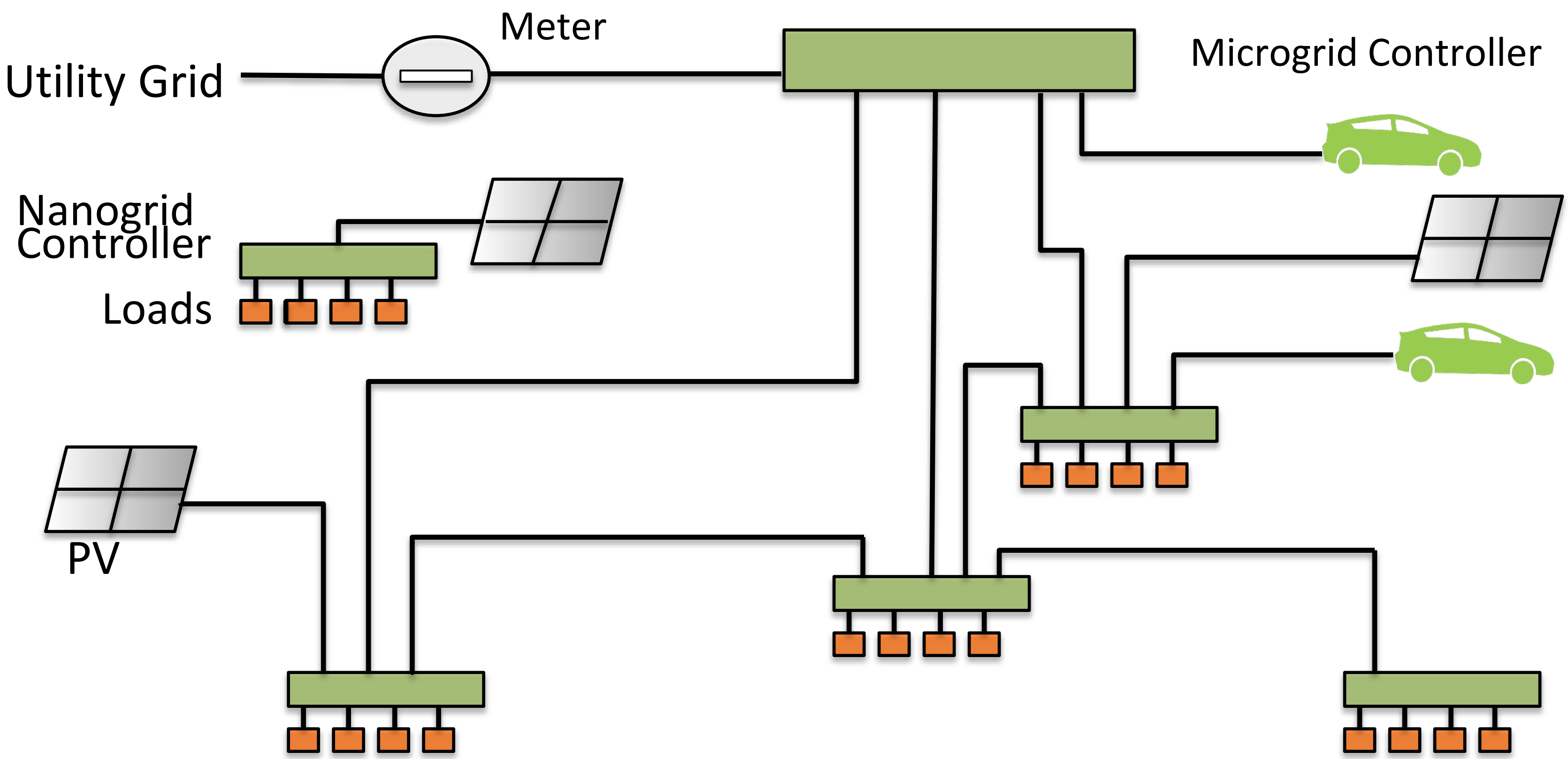


Services in apis-main



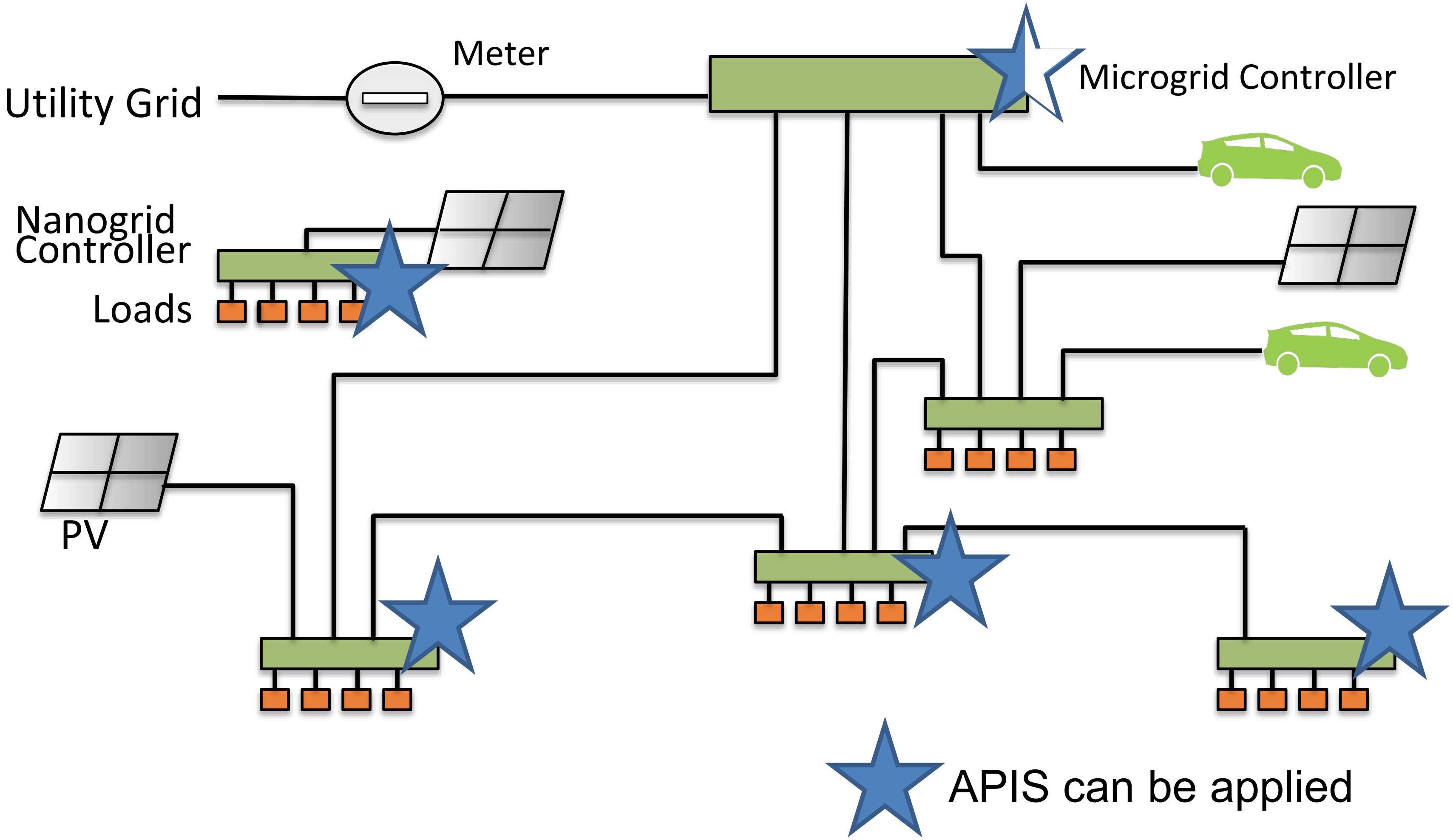
Slide from Bruce

"Networked Electricity" - Example local grid network



Slide from Bruce’s Local Power Grid Deck

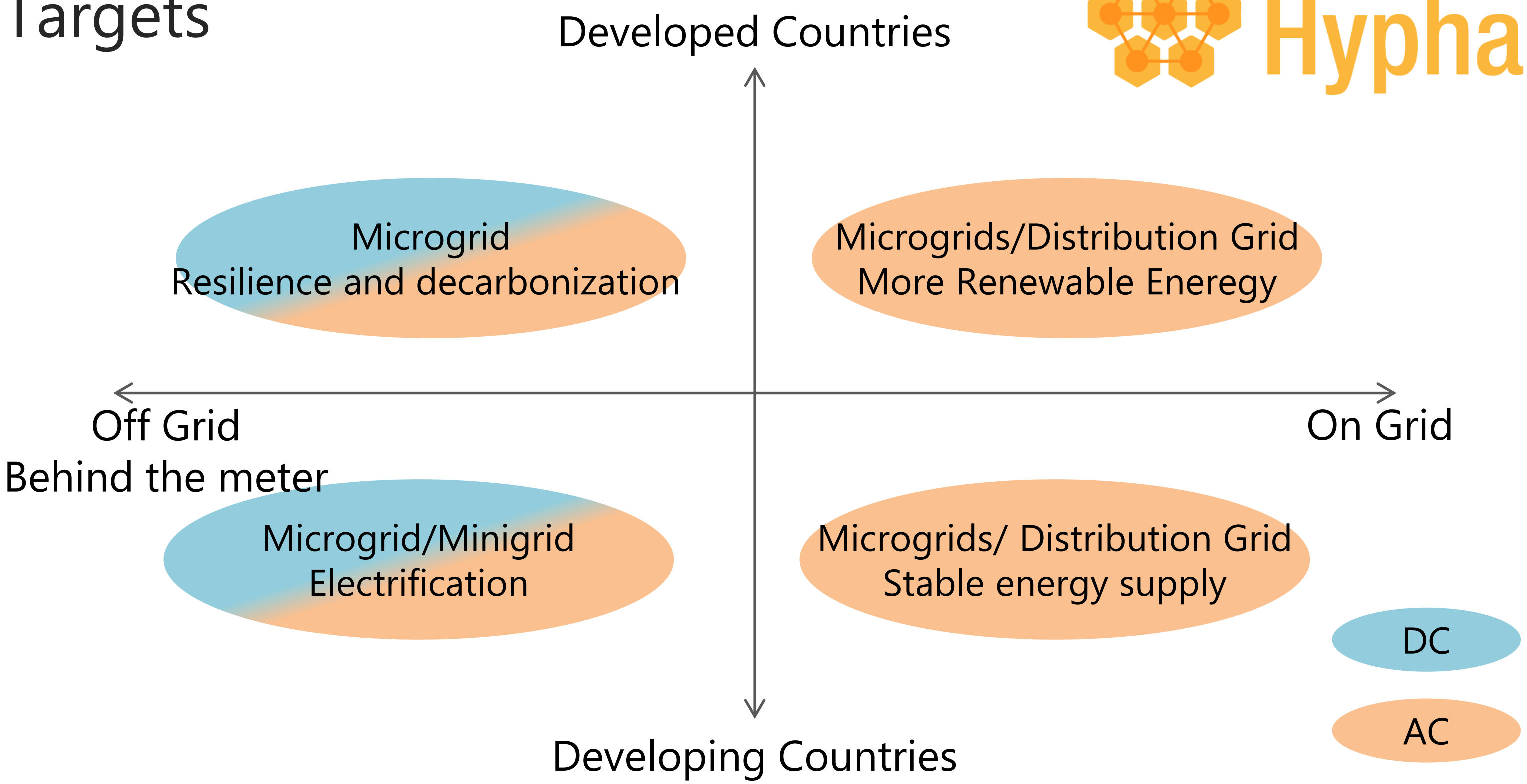
“Networked Electricity” - Example local grid network



Next steps

- APIS with Physical P2P Energy sharing can accelerate more renewable energy installation with smaller amounts of batteries.

- Targets



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