ICT and energy

Warm-up

- What is your programming experience?
- Which programming languages you know?
- What is your experience with Artificial Engineering?

Energy efficiency of programming languages

Energy efficiency of programming languages

- Source: https://thenewstack.io/which-programming-languages-use-the-least-electricity/

	Energy
(c) C	1.00
(c) Rust	1.03
(c) C++	1.34
(c) Ada	1.70
(v) Java	1.98
(c) Pascal	2.14
(c) Chapel	2.18
(v) Lisp	2.27
(c) Ocaml	2.40
(c) Fortran	2.52
(c) Swift	2.79
(c) Haskell	3.10
(v) C#	3.14
(c) Go	3.23
(i) Dart	3.83
(v) F#	4.13
(i) JavaScript	4.45
(v) Racket	7.91
(i) TypeScript	21.50
(i) Hack	24.02
(i) PHP	29.30
(v) Erlang	42.23
(i) Lua	45.98
(i) Jruby	46.54
(i) Ruby	69.91
(i) Python	75.88
(i) Perl	79.58

So, is the first task to learn a new programming language?

Content of this lession

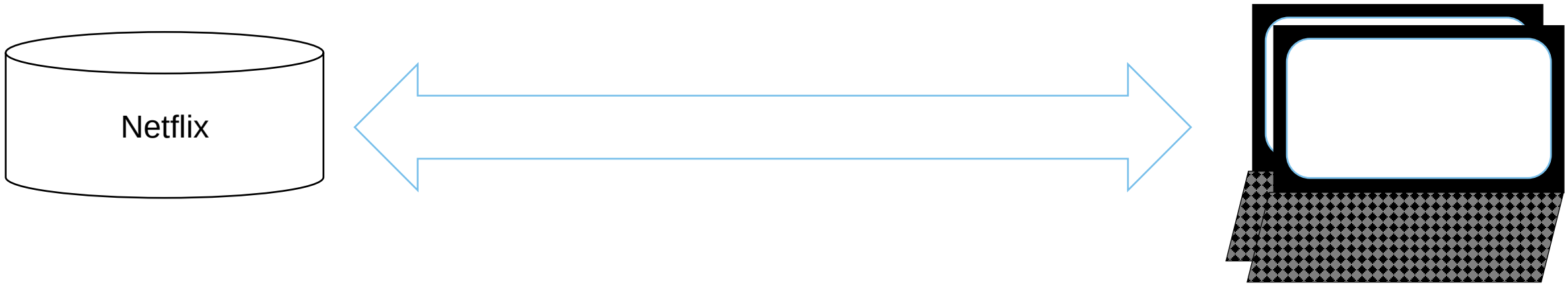
- Energy comsumption of ICT and software
- ICT, data and software for sustainable energy systems
- Data in energy research

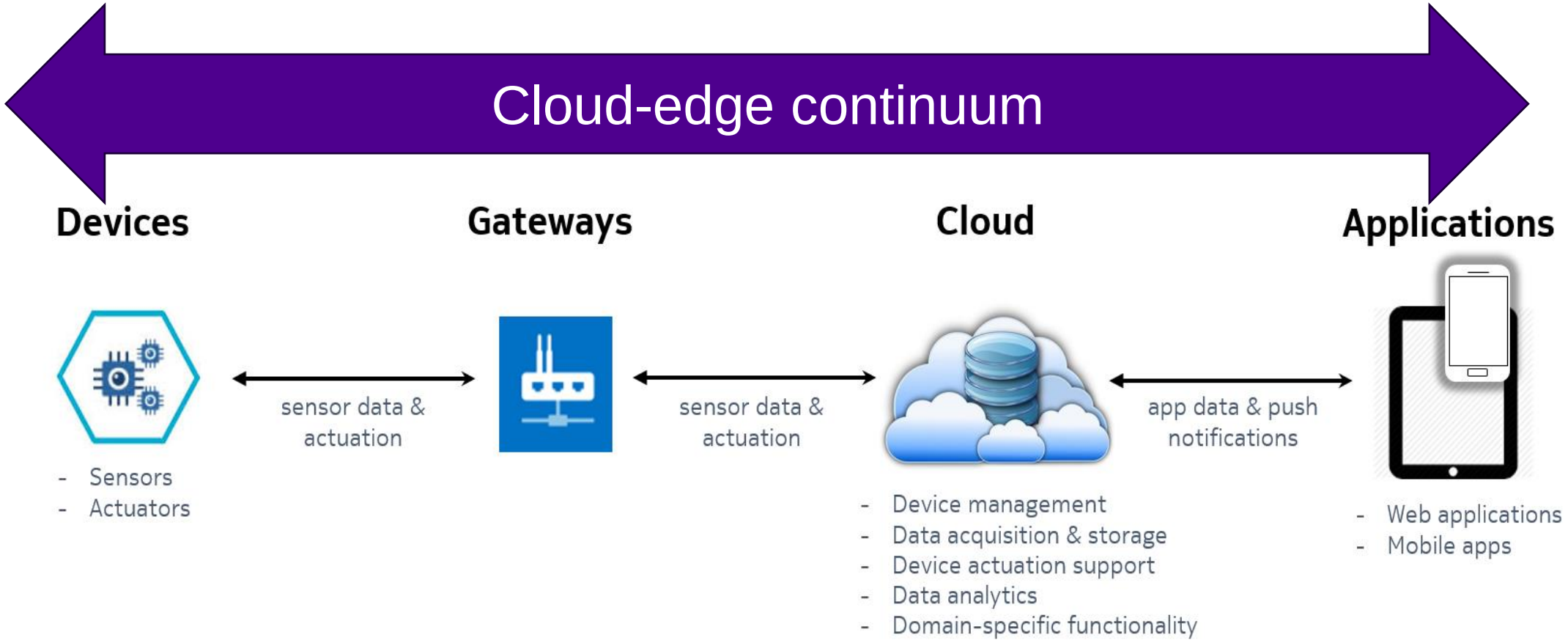
About me

- Doctor of technology (software systems)
- 16.5 years in various position at Nokia corporation
- Back to university beginning of 2012
- CNESS-related research
  - Cross-disciplinary research: procumers, energy communities
  - Data collection, management and sharing
- Nerd

Energy consumption of ICT

How much energy is consumer – hard to say




Cloud-edge continuum
Devices
Gateways
Cloud
Applications
sensor data & actuation
sensor data & actuation
app data & push notifications
- Sensors
- Actuators
- Device management
- Data acquisition & storage
- Device actuation support
- Data analytics
- Domain-specific functionality
- Web applications
- Mobile apps

What do existing research say

- By some estimates, the carbon footprint of our gadgets, the Internet, and the systems supporting them account for about 3.7% of global greenhouse emissions.
- The share of the ICT sector in global greenhouse gas emissions is growing much more faster than that of any other sector, adding up to estimates between 2.1% and 3.9% —which is on par with aviation.
- This was before ChatGPT!

Some googling

- According to estimates, a google search uses 0.3 Wh
- Every day google gets 8.5 billion searches
- => 2.5 GWh / day => 1 TWh / year

- ChatGPT “search” uses 25 times the google search

- There are other estimates – reliable data is missing

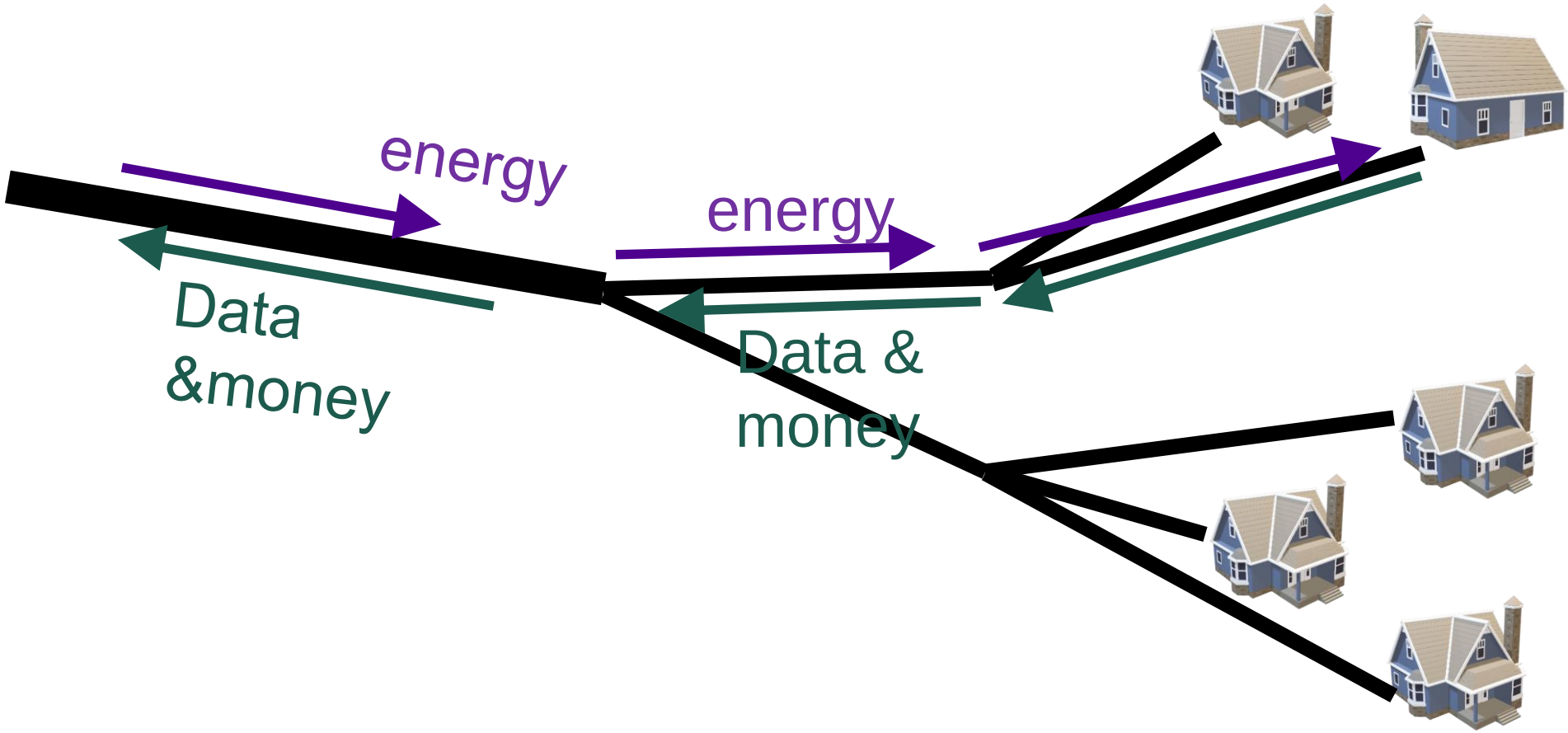
ICT and energy consumption; main points to remember

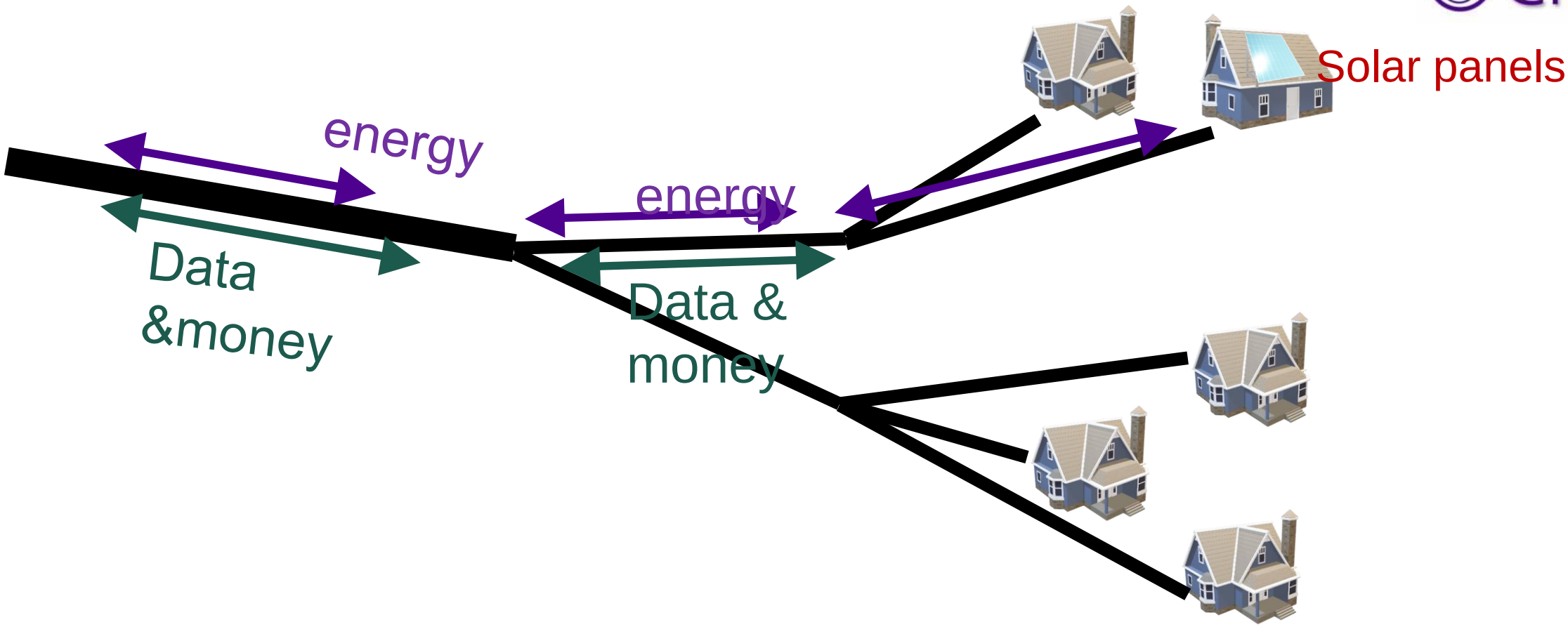
- Estimation for individual internet activity does not make sense; analysis should have a systematic view
  => but you should still care
- CO_2 emission about same as aviation
- Share of emissions is growing
- Watch after the current AI boom!

Energy systems and ICT

Drivers

- Reliability
- Measuring and monitoring
- Energy saving
- Flexibility
- Use of renewable energy
- Distributed production


energy
energy
Data
&money
Data &
money


Solar panels
energy
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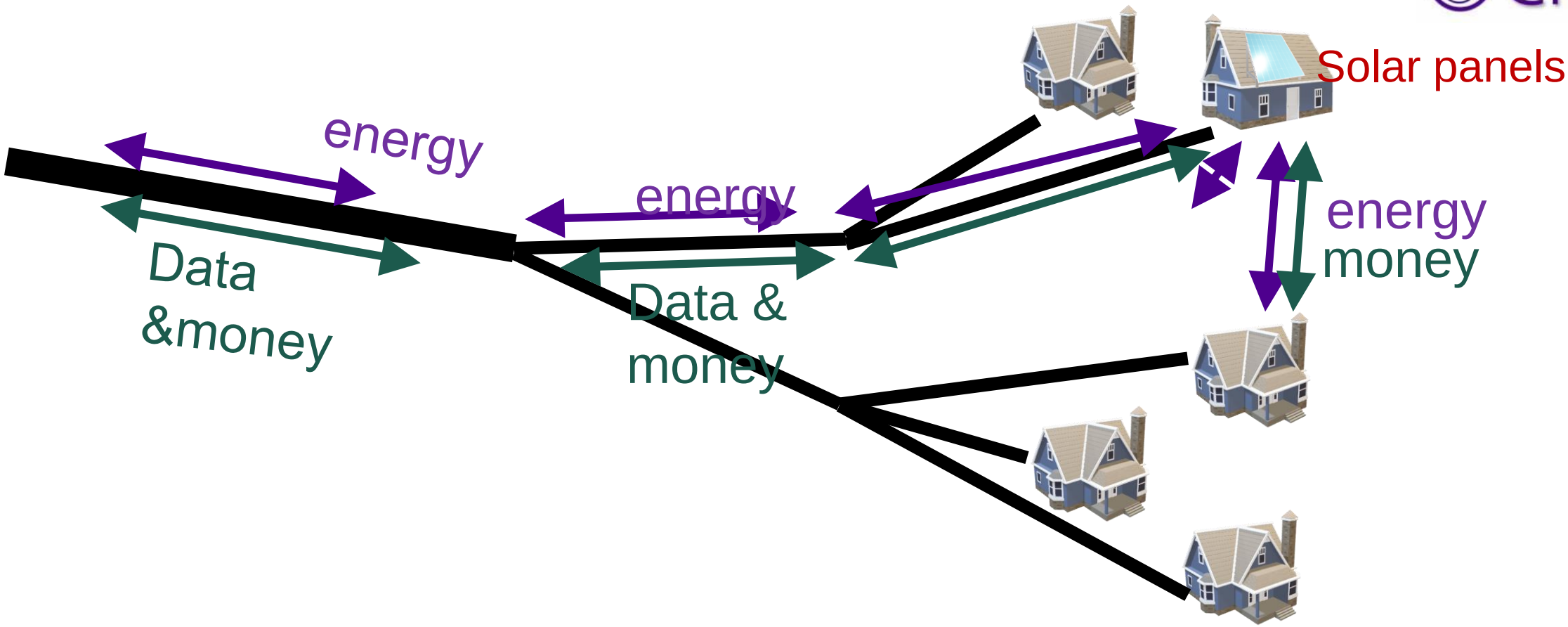
Solar panels
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Data
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Data &
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energy
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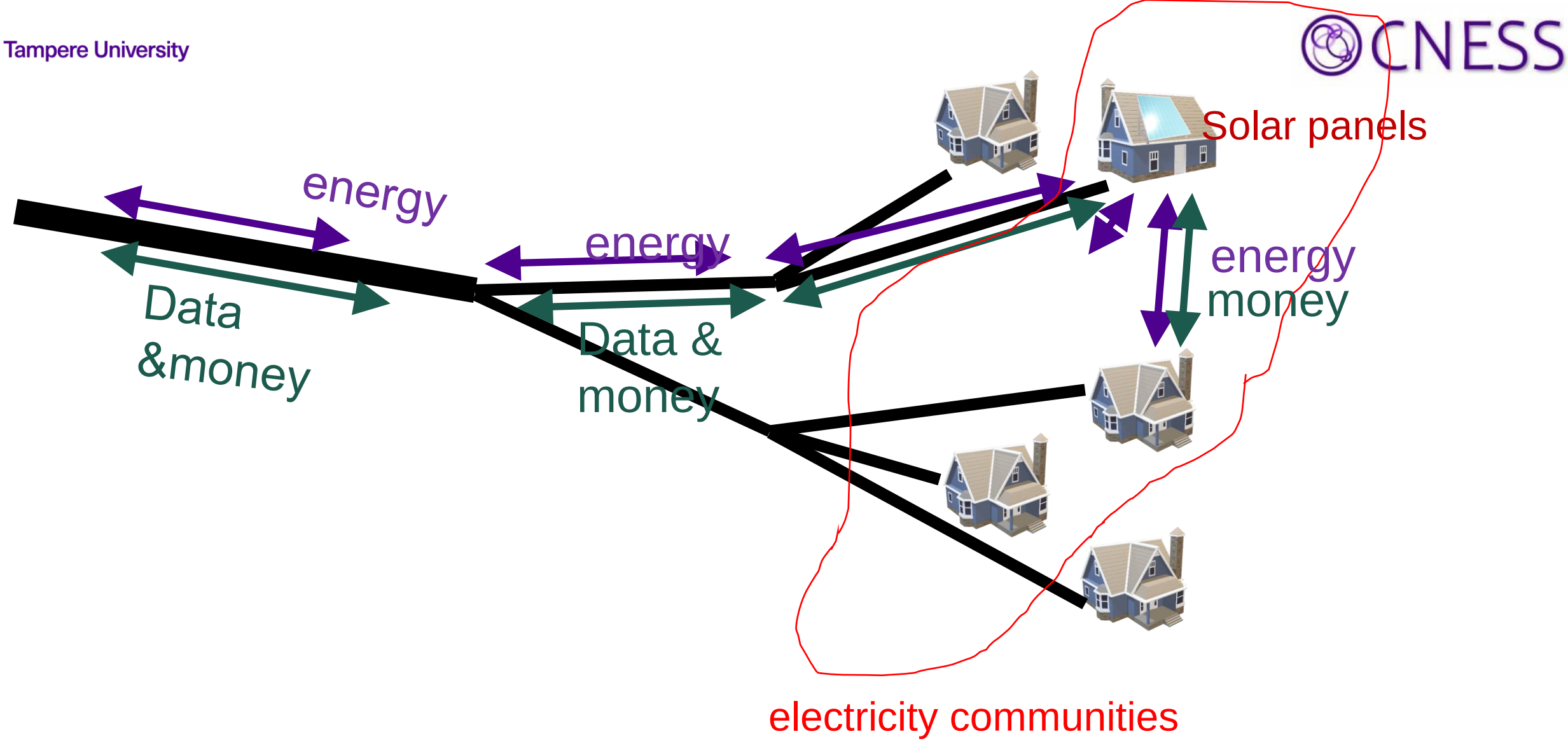
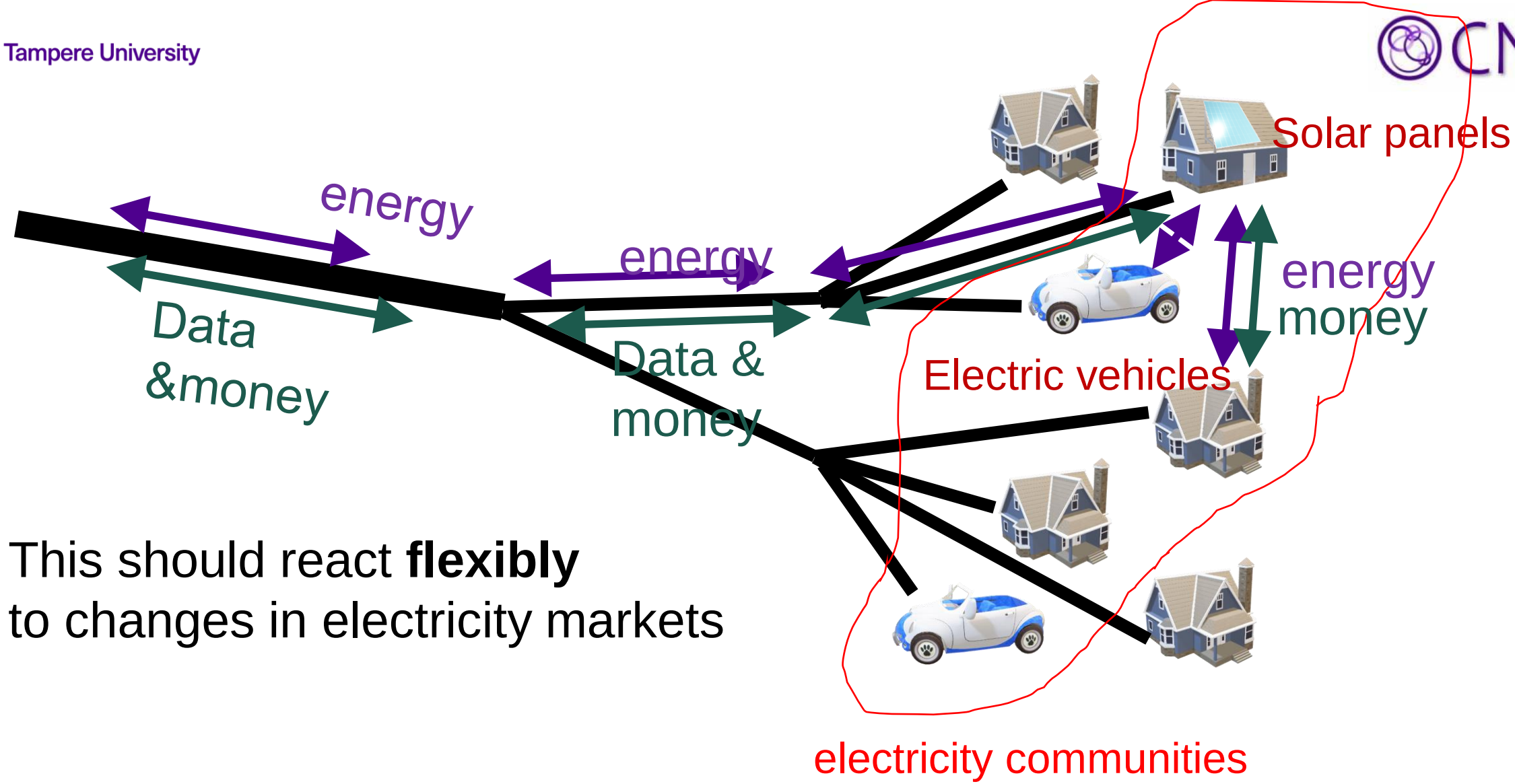
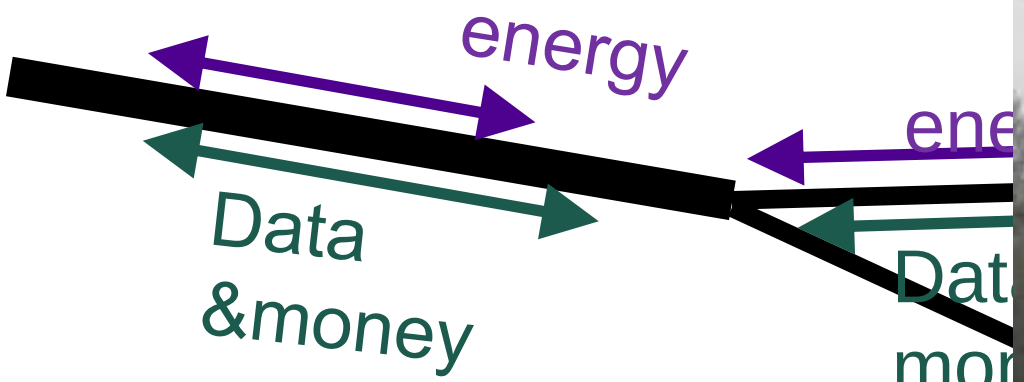

Tampere University
CNESS
Solar panels
energy
energy
Data
&money
Data &
money
energy
money
electricity communities

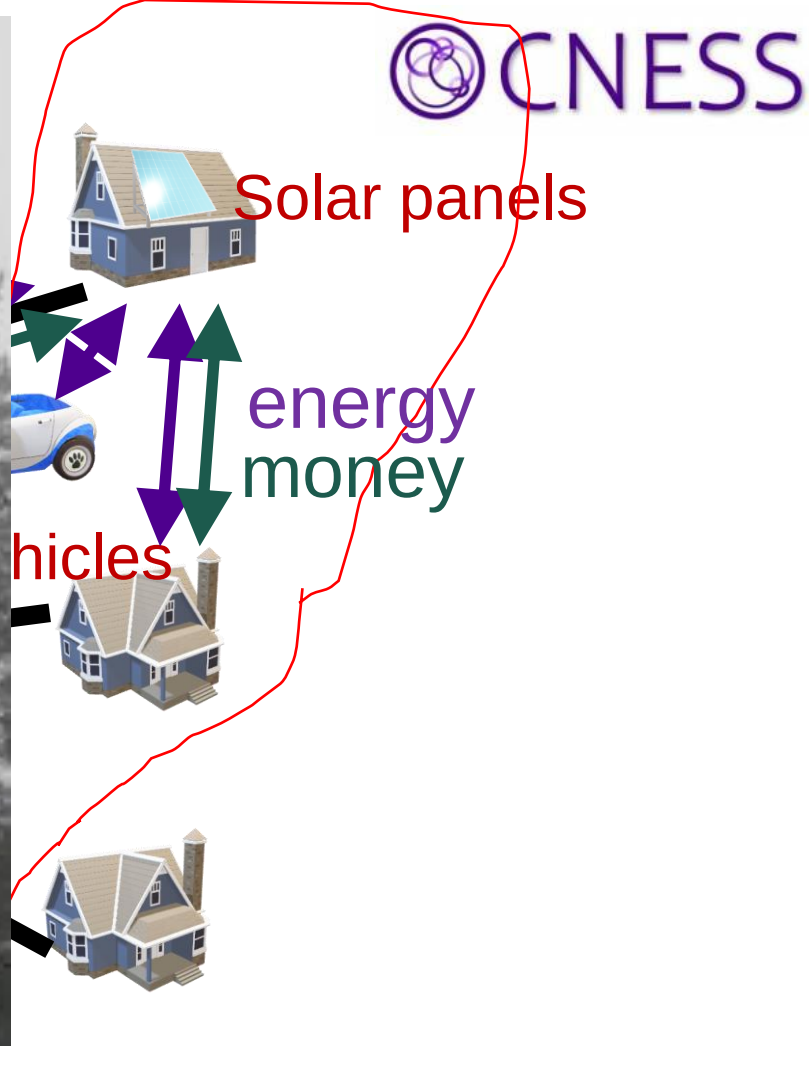


This should react **flexibly**
to changes in electricity markets

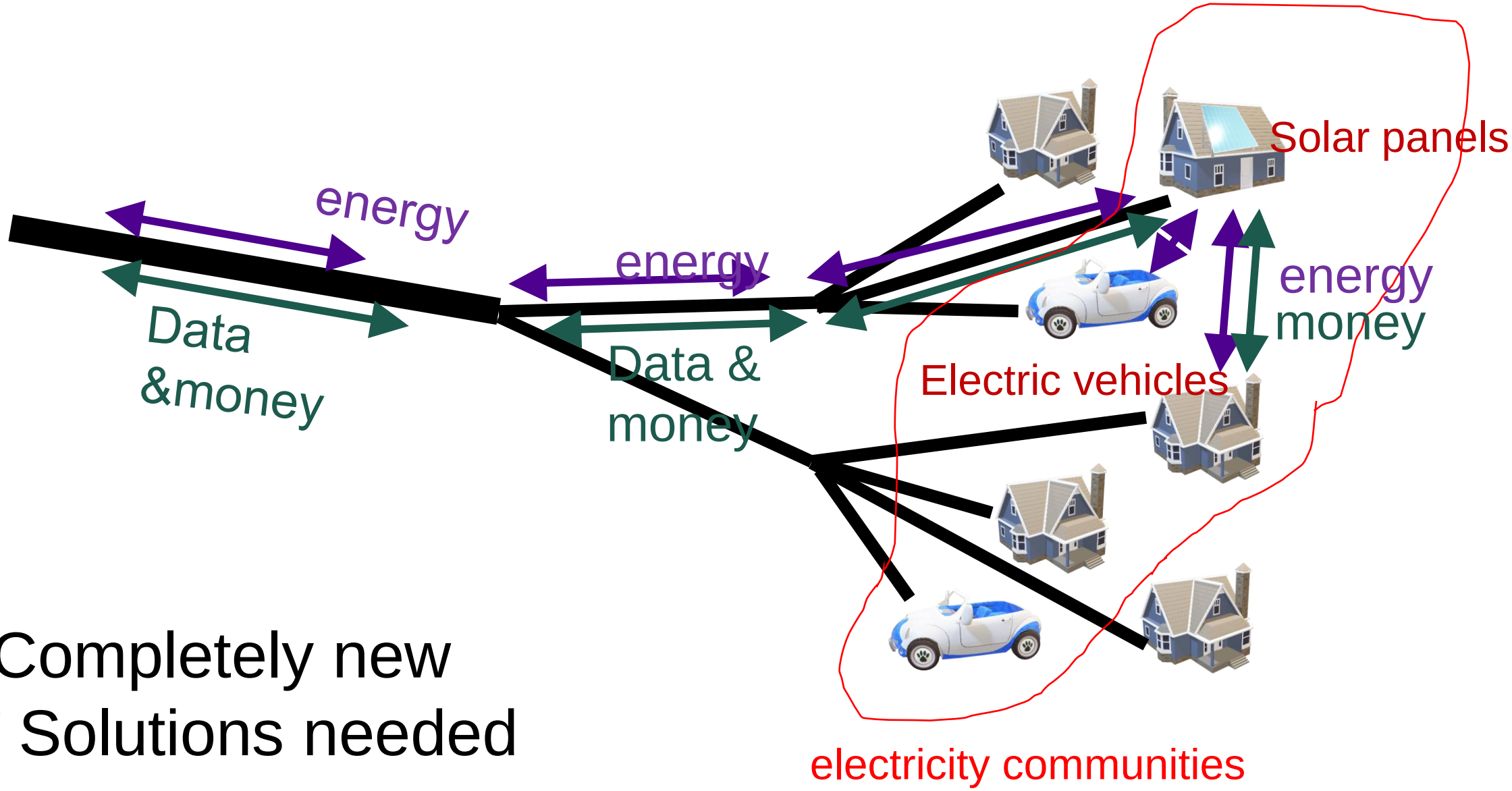
Tampere University

CNESS





This should react flexibly
to changes in electricity market



=> Completely new
ICT Solutions needed

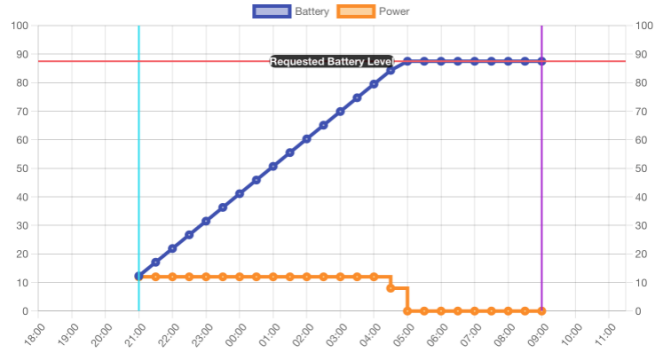
User_1 - Station ID: 1

BATTERY CAPACITY : 125KWH MAX POWER INPUT : 12.4KW

INITIAL BATTERY : 12.3% REQUESTED BATTERY: 87.5% FINAL BATTERY: 87.50%

ARRIVAL TIME : 23/01/2023, 21:00:00 TARGET TIME : 24/01/2023, 09:00:00

STATION MAX POWER : 12.5KW



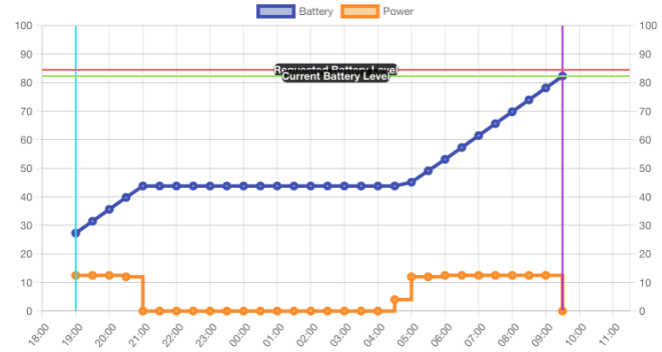
User_2 - Station ID: 2

BATTERY CAPACITY : 150KWH MAX POWER INPUT : 15.5KW

INITIAL BATTERY : 27.3% REQUESTED BATTERY: 84.5% FINAL BATTERY: 82.30%

ARRIVAL TIME : 23/01/2023, 19:00:00 TARGET TIME : 24/01/2023, 09:30:00

STATION MAX POWER : 12.5KW



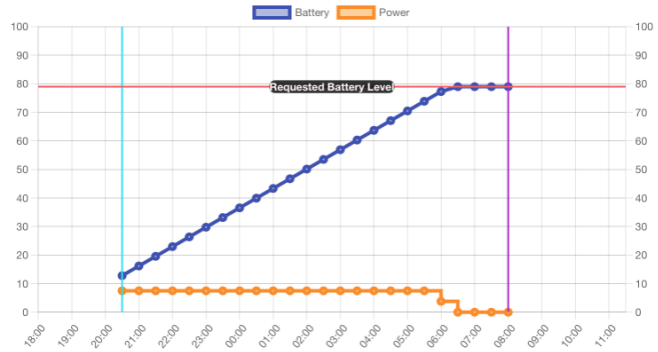
User_3 - Station ID: 3

BATTERY CAPACITY : 110.5KWH MAX POWER INPUT : 7.5KW

INITIAL BATTERY : 12.8% REQUESTED BATTERY: 79% FINAL BATTERY: 79.00%

ARRIVAL TIME : 23/01/2023, 20:30:00 TARGET TIME : 24/01/2023, 08:00:00

STATION MAX POWER : 12.5KW



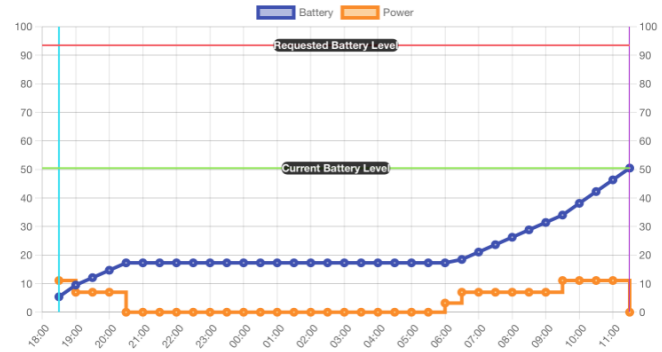
User_4 - Station ID: 4

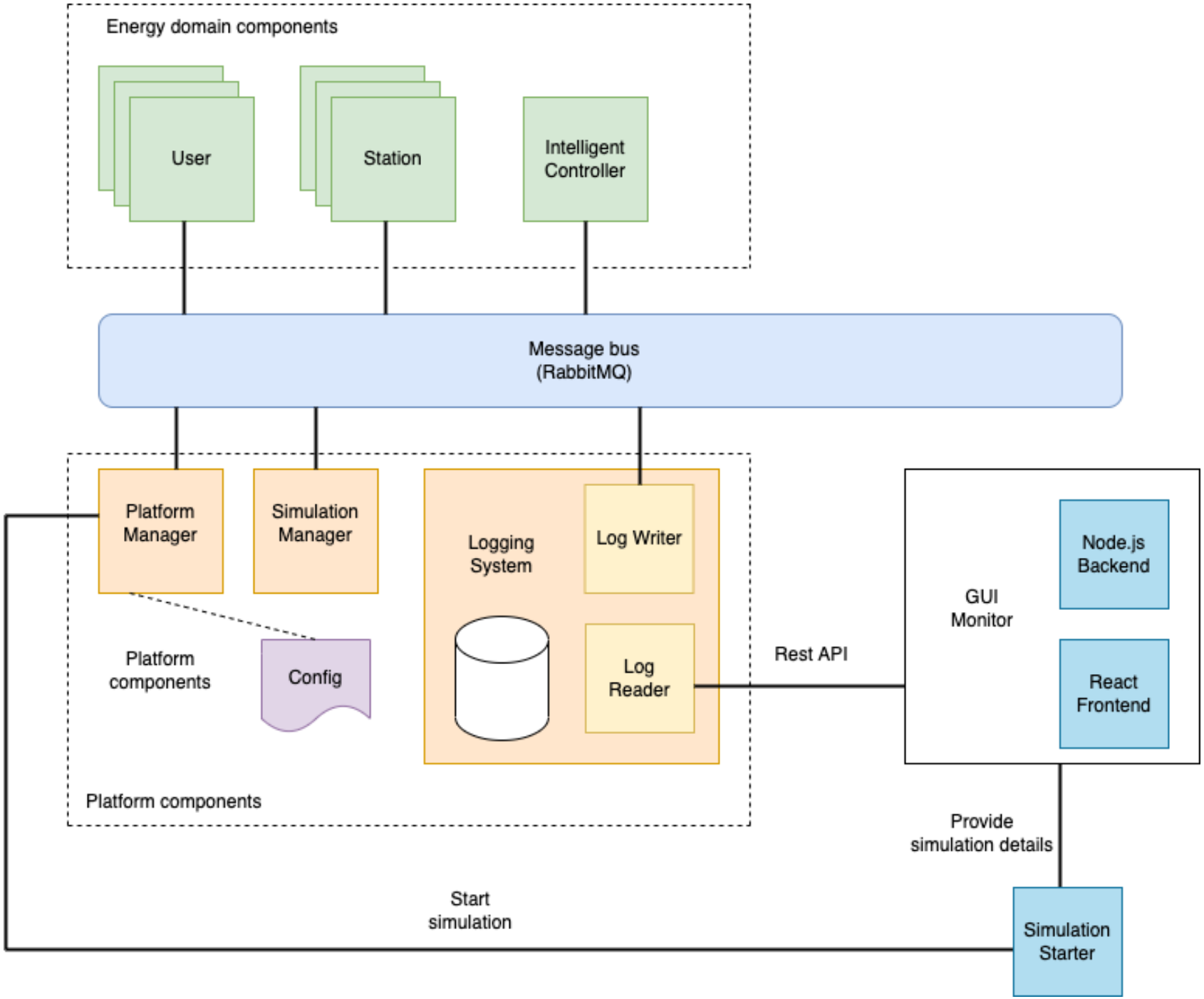
BATTERY CAPACITY : 135KWH MAX POWER INPUT : 11.1KW

INITIAL BATTERY : 5.4% REQUESTED BATTERY: 93.5% FINAL BATTERY: 50.47%

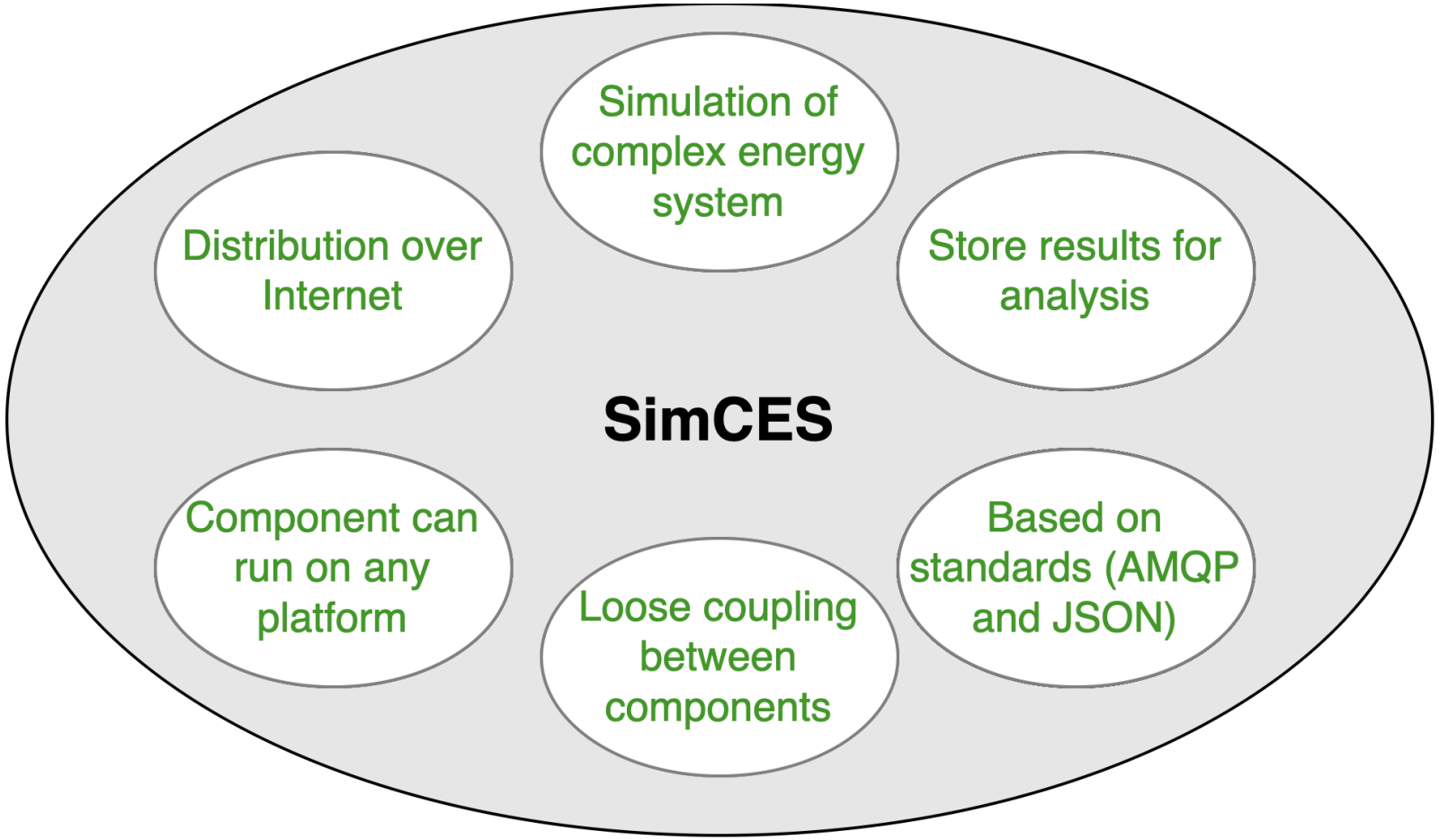
ARRIVAL TIME : 23/01/2023, 18:30:00 TARGET TIME : 24/01/2023, 11:30:00

STATION MAX POWER : 12.5KW




Energy domain components
User
Station
Intelligent Controller
Message bus (RabbitMQ)
Platform Manager
Simulation Manager
Logging System
Log Writer
Platform components
Config
Log Reader
Rest API
GUI Monitor
Node.js Backend
React Frontend
Platform components
Provide simulation details
Start simulation
Simulation Starter

SimCES | Simulation Environment of Complex Energy Systems



https://simcesplatform.github.io

Role of Data


KAMPUSAREENA

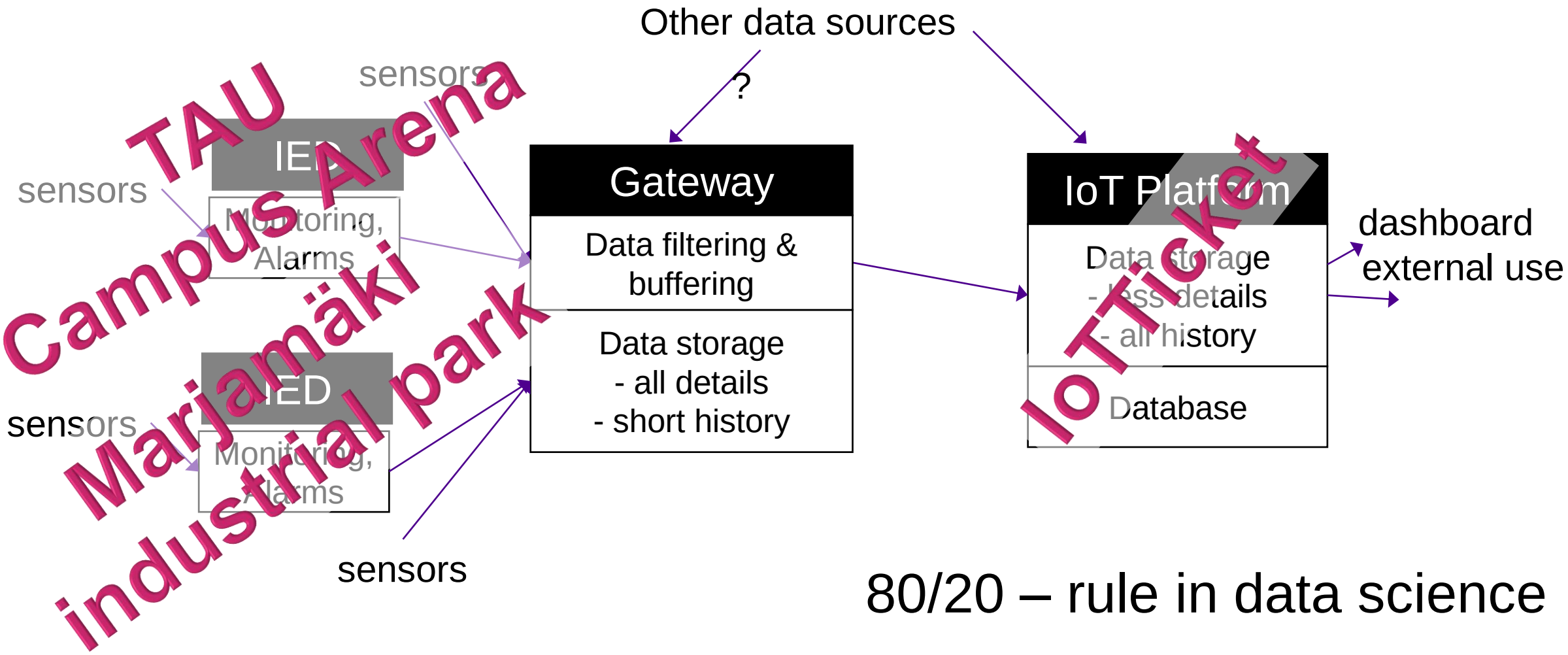
Tampere University

Data sources for ProcemProject

CNESS

Source	Device	Connection	Protocol
Power quality measurement	Laatuvahti (MX Electrix)	Ethernet	TCP (Proprietary)
Solar power plant	SMA PV inverters	Ethernet	Modbus TCP/IP
Building automation	Siemens (Desigo)	BACnet	BACnet
Weather	Vaisala weather station	Internet	SQL database
Battery	Build by TUT	CAN/Ethernet	Modbus TCP/IP
Power consumption	ISS mittauskeskitin	Ethernet	Modbus TCP/IP
Weather forecast	FMI web service	Internet	REST
Electricity price	Fingrid / Nordpool	Internet	REST

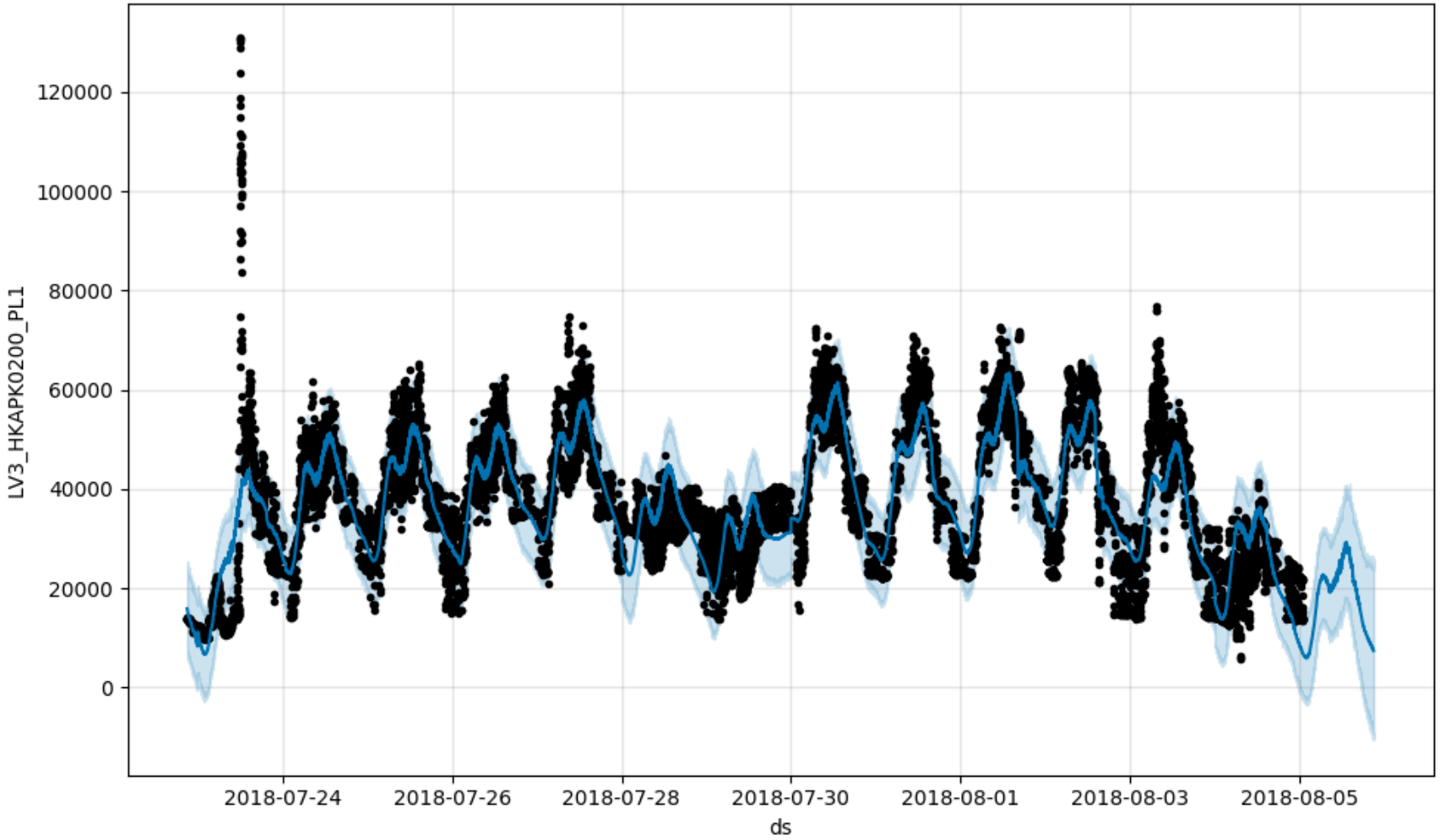
Data-collection architecture of Procem and ProcemPlus projects

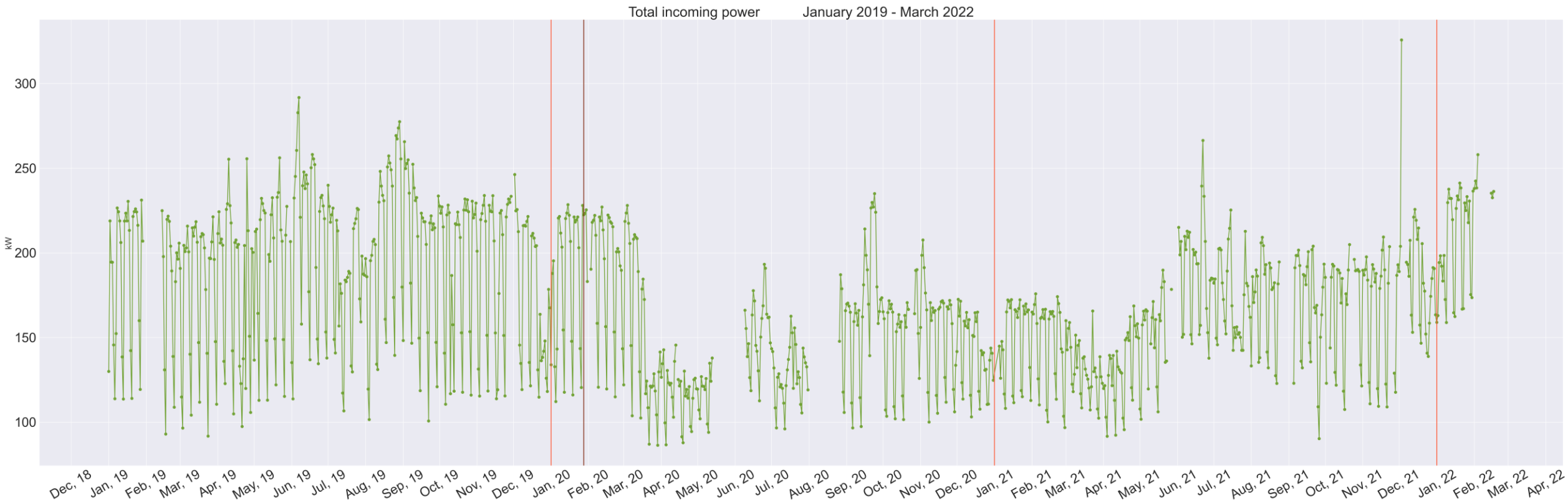


80/20 – rule in data science

Time series

- Python + Prophet
- Weather forecasts




Total incoming power
January 2019 - March 2022
kW
300
250
200
150
100
Dec, 18
Jan, 19
Feb, 19
Mar, 19
Apr, 19
May, 19
Jun, 19
Jul, 19
Aug, 19
Sep, 19
Oct, 19
Nov, 19
Dec, 19
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Feb, 22
Mar, 22
Apr, 22

https://www.fingrid.fi/en/electricity-market/datahub/

- Datahub is a centralised data exchange system for the electricity retail market, storing information on around 3.8 million electricity points of use. Approximately 80 distribution system operators (DSOs) responsible for electricity transmission and 80 electricity suppliers have switched to the centralised information exchange system, Datahub. The system provides secure, fair and up-to-date access to data for all authorised parties. You can access customer and consumption data for your own electricity usage points via the datahub customer portal.

Now, a group work

Group work

In your PhD research:

- What kind of data you use?
- What kind of data you miss?
- What kind of data you could share?

Example(s) about our current work

Background & motivation

- Multiple projects have collected energy research data that could be used by other researchers
- Currently, no way to tell about or find this kind of data
- Various aspects of the data need documenting: what's it about, how is it stored, what is the format, how to access it, who owns it, under what permissions it can be used.
- Dataspace thinking: everyone stays in control of their data, no common storage system or formats, instead tools to help collaboration.

Examples of data

- ProCem and ProCemPlus projects collected data from Kampusareena and Marjamäki micro-grid
- CityIoT project collected data from street lights and electric buses in Tampere
- TAU has been given access to data collected from the new Ilokkaanpuisto residential area which includes data from apartment buildings and a solar power plant.
- In each case data is stored and accessed in a different way and availability of the data is not well known outside of the involved people

Our proposed solution

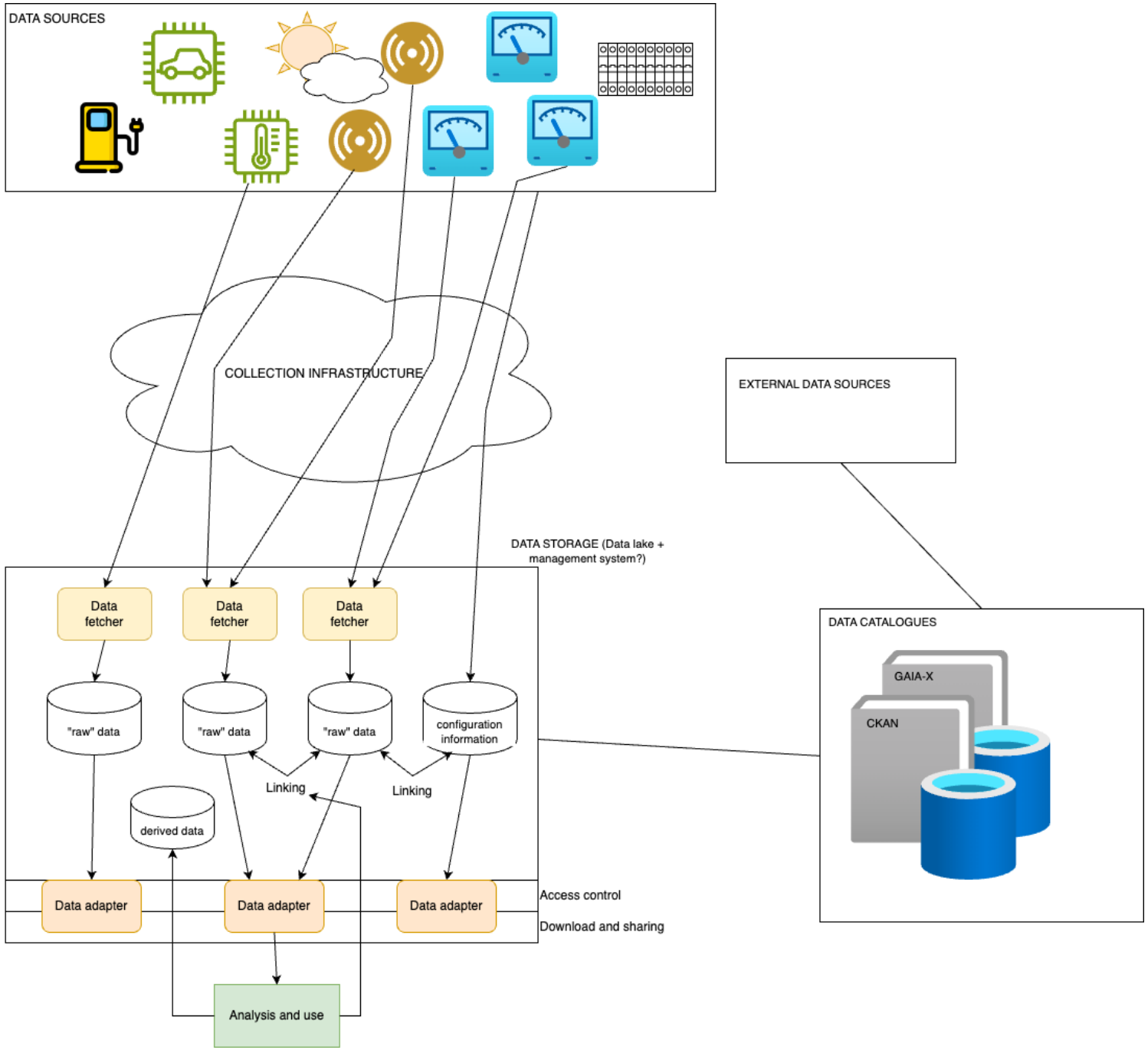
- Use the open source CKAN data management platform to create a energy research data catalog web page
- CKAN is used widely around the world to distribute open data: for example goverments of Canada and Australia, Helsinki region and Fingrid
- For us it would be mainly a place to document the data and find it, and the data itself is stored elsewhere
- Content is public, only documenters need an account.
- Open source allows us to administer CKAN ourselves and customise it to suit our needs.

Challenges

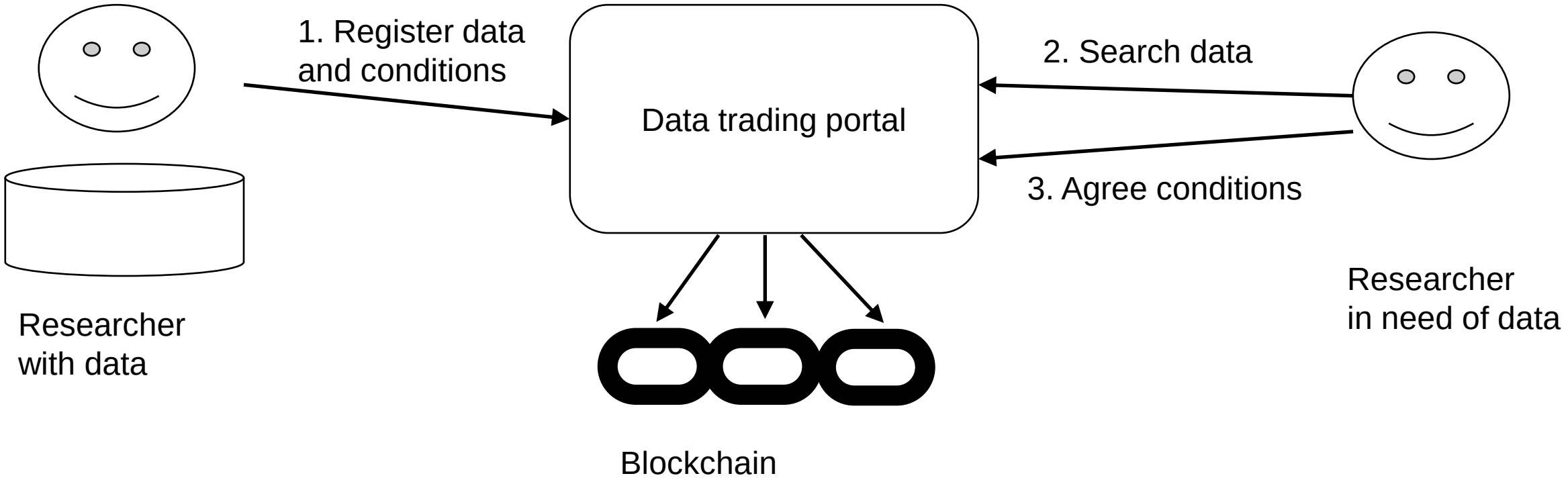
Interoperability: Dataformats and datamodels – or adapters

Data collection, storing and (technical) access

Data ownership, sharing and privacy


DATA SOURCES
COLLECTION INFRASTRUCTURE
EXTERNAL DATA SOURCES
DATA STORAGE (Data lake + management system?)
Data fetcher
Data fetcher
Data fetcher
"raw" data
"raw" data
"raw" data
configuration information
Linking
Linking
derived data
Data adapter
Data adapter
Data adapter
Access control
Download and sharing
Analysis and use
DATA CATALOGUES
GAIA-X
CKAN

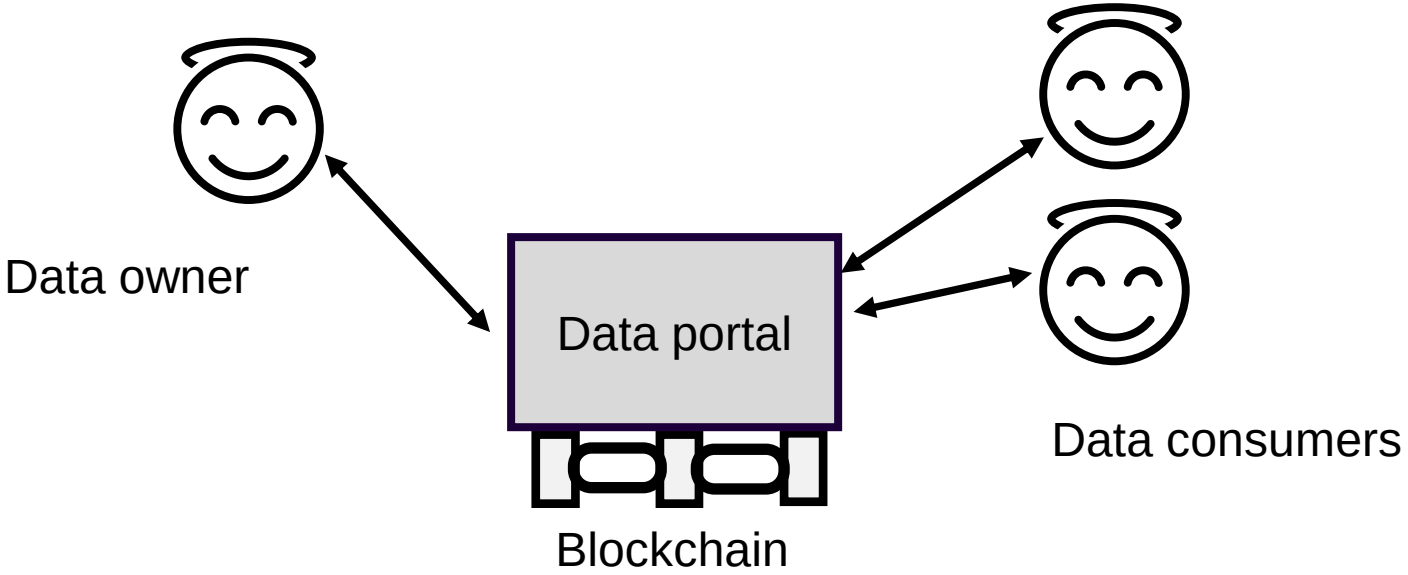
Data “trading” point



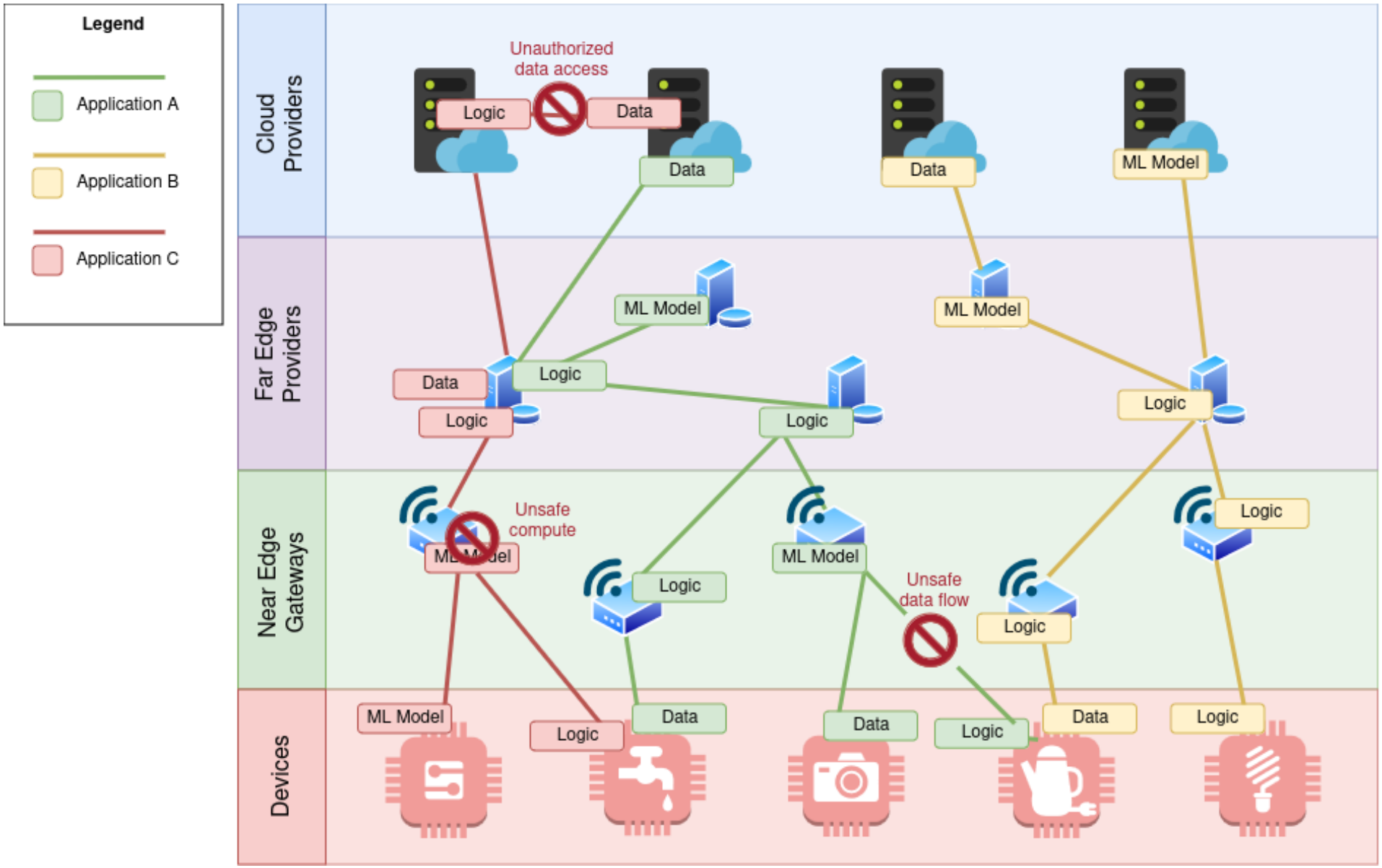
Related research

Otto Hylli, David Hästbacka, Kari Systä

Towards managed sharing of research data



- EU Cyber Resilience Act
- EU AI Act
- GDPR
- EU Data Act


Legend
Application A
Application B
Application C
Cloud Providers
Far Edge Providers
Near Edge Gateways
Devices
Unauthorized data access
Logic
Data
Data
Data
ML Model
ML Model
ML Model
Data
Logic
Logic
Logic
Logic
Unsafe compute
ML Model
Logic
ML Model
Unsafe data flow
Logic
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ML Model
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