Strategy for selection of IoT management technology: from SMS to AWS

Leonid Karpenko, Sergey Dushin

Synergy team / Institute of control science of RAS

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- PROBLEM: «WHAT TECH. TO USE FOR OUR PROJECT»
- IOT CONNECTIVITY
- IOT UPPER LEVEL SYSTEMS
- SELECTION ALGORITHM
- EXAMPLES

PROBLEM: WHAT TECHNOLOGY TO USE FOR SPECIFIC IOT PROJECT

MANIFOLD OF IOT APPLICATIONS

Internet of Things (IoT)

- Smart Grid, eMeter management
- Smart home / building
- Industrial automation
- Asset tracking
- Smart city
- Smart road
- Medical and health care
- Vehicle control
- Communication networks management
- Precision agriculture

MANIFOLD OF IOT TECHNOLOGIES

DATA TRANSPORT TECHNOLOGIES

LoRaWAN

ZigBee

NB-IoT

LTE-M

PRIME ALLIANCE

G3-PLC Alliance

Modbus over RS485

BUS 77

UPPER LEVEL SYSTEMS

aws

ThingsBoard

MQTT

Azure

OPC UA

OpenSCADA

Open supervisory control and data acquisition project

MasterSCADA

Modbus

Invensys Wonderware

SNMP

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PROBLEM TO DISCUSS

What will be the optimal:

- data transport
- upper level system

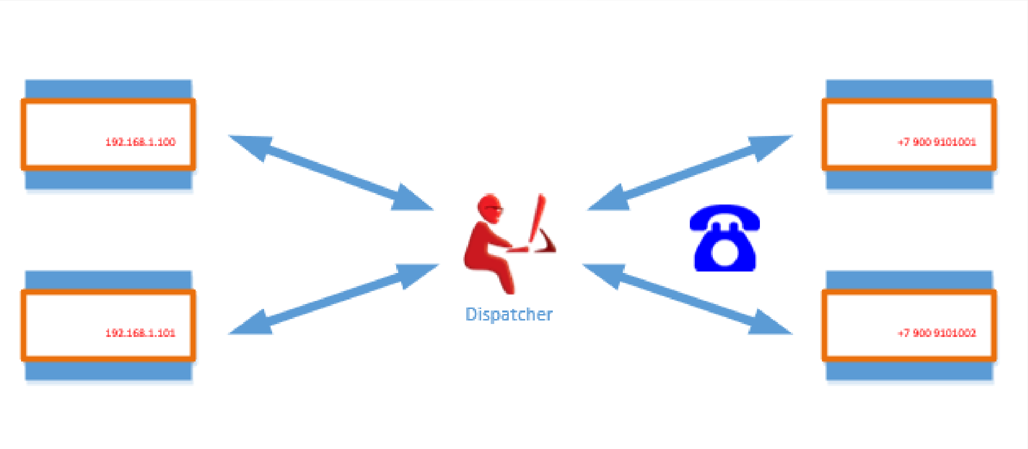
for specific IoT project

IOT CONNECTIVITY

SERVERLESS CONNECTION: SMS or FIXED IP

Pros (+):

- Easiest to implement
- no cost of Upper level & integration
- No special management SW required



Cons (-):

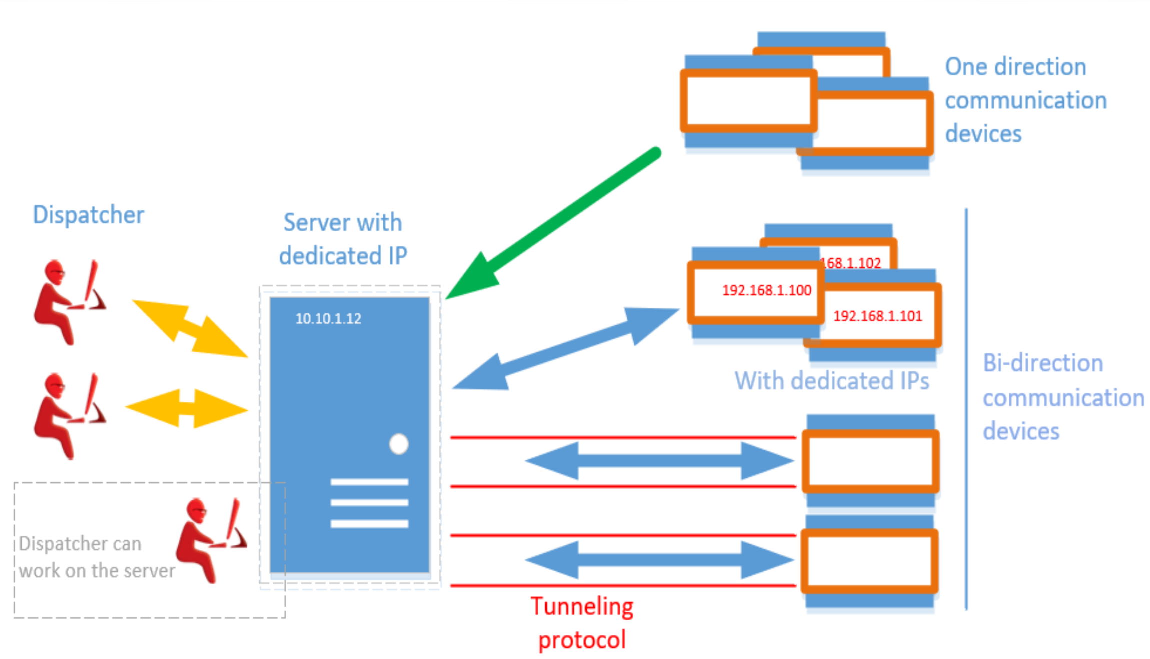
- Compex to manage and analyse
- Even more complex when N of objects increases
- Big SMS or fixed IP fees
- Low cyber security
- Long to configure with operator (e.g. arrange APN)

SMS is an easiest way to communicate and still suitable for simple projects

DIRECTLY CONNECTED IoT
(device <> fixed IP server)

Pros (+):

- Easy to arrange with network operator
- Convenient to configure and work
- Controllers don't need fixed IPs (no extra cost most cases)



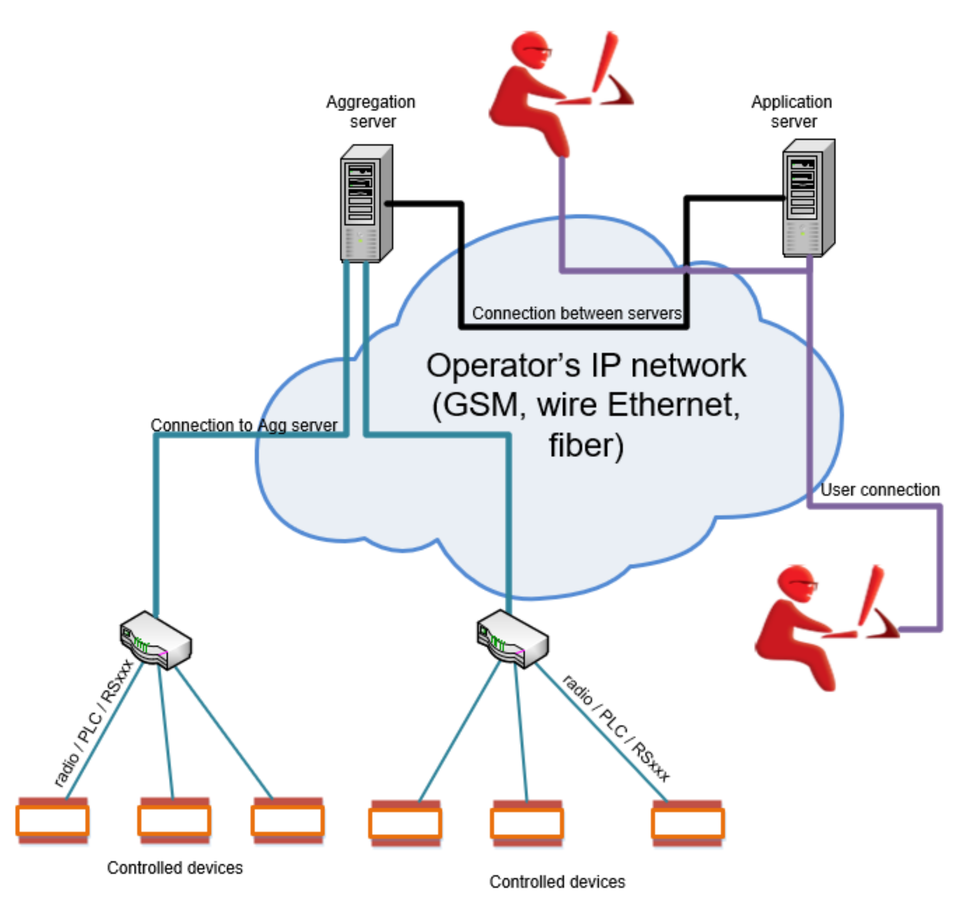
Cons (-):

- Expensive IoT devices (should support IP stack)
- High power consumption (problem if battery powered)
- Work only if telecom network available

PRIVATE HUB CONNECTED IOT

Pros (+):

- Hubs can be placed when needed
- no fee (except for use of operator's network) - low OPEX
- Different HUBs can be of different types: wired, radio, etc.



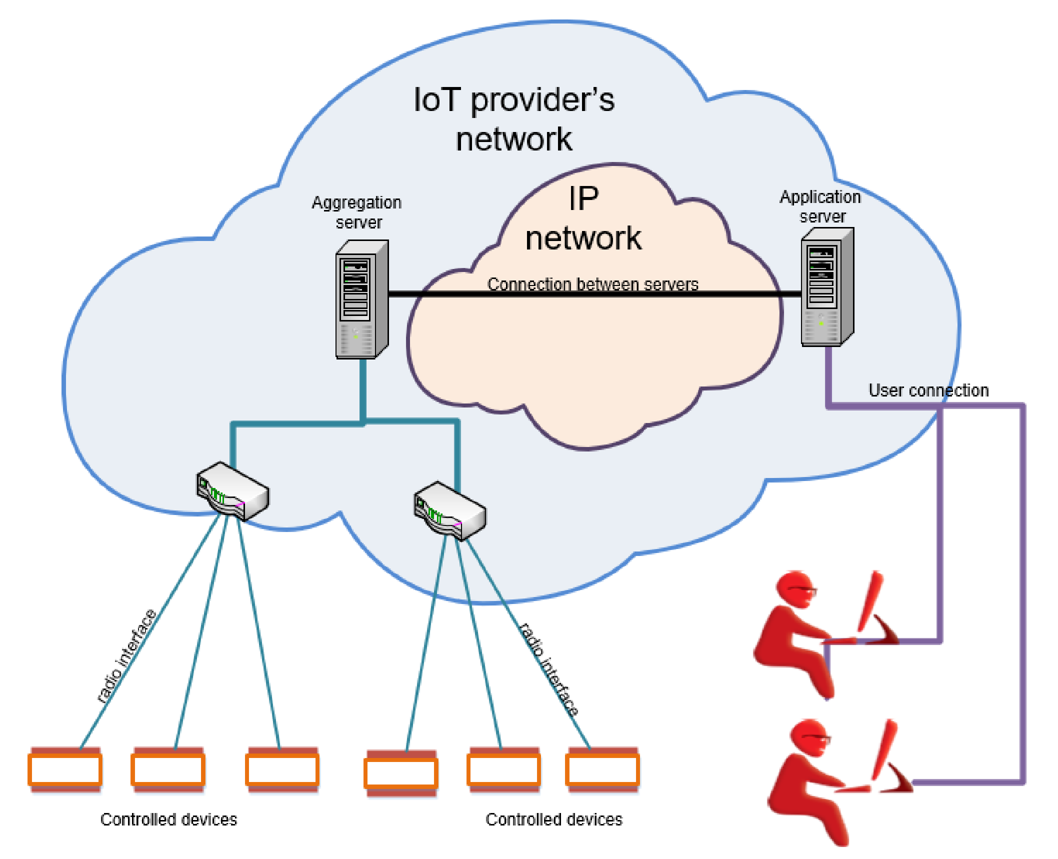
Cons (-):

- Maintenance is needed
- High CAPEX expenses (to build every HUB/BS)
- Slow deployment

OPERATOR’ s HUB CONNECTED IOT

Pros (+):

- Low expenses to deploy the network (low CAPEX)
- Fast deployment
- Maintenance not needed (except App. server)



Cons (-):

- Fee for every connected device (high OPEX)
- Possible problems with radio coverage
- Long to agree with operator for non-standard cases
- all operator’s HUB’s are normally of one type (like LoRA / NBoT)

TRANSPORT LAYER TECHNOLOGIES

Direct-connected and serverrless technologies

Transport layer	Physical layer	Range (free air/wire hop), km	Max. speed (typically), kbps
SMS	radio	1	0.5
Wired Ethernet 100M	wire	0.1	1e5
Wired Ethernet 1G	wire	0.1	1e6
Wi-Fi (optimized to IoT)	radio	0.03	2e4
Cell (2G GPRS typ.)	radio	1	50
Cell (3G minimum)	radio	1	200
Cell (4G minimum)	radio	1	200
Fiber (GPON)	wire	20	1,2e6

HUB-connected tech.

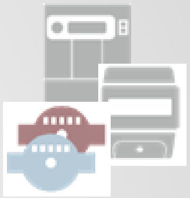
Transport	Phy. layer	Range, km	Speed, kbps
LoRaWAN	radio	5	0.2
NB-Fi (Rus)	radio	10	0.3
SigFox	radio	10	0.05
ZigBee	radio	0.5	30
PLC (PRIME, G3, etc.)	wire	0.5	200
NB-IoT	radio	1	20
RS485, CAN, etc.	wire	2	20

TO BE CONTINUED...

IOT UPPER LEVEL SYSTEMS

READY TO USE SW PRODUCTS

Following types of SW products can be used for IoT:



- SCADA for Industrial automation (OPC, ModBus)
- Network management systems (SNMP, TR-069, CLI)
- Automated meter management (AMM) of heat, electricity, gas, water
- Objects tracking (navigation)
- Heating, ventilation, air conditioning, climate control (HVAC), "Smart" home / office / building
- Management of energy facilities: substations, outdoor (street) lighting, charging stations for electric transport
- Access control and security and fire safety, etc.

Pros (+):	Cons (-):
• Time tested • High control (can be deployed in a safe customer data center) • Low start OPEX	• High license price (for many objects) • Weak control over the system (no source code, difficult to maintain) • Some systems can be used only as SaaS (not possible for B2G/big business) • SW vendor = future competitor

DEVELOPMENT ON CLOUD IOT PLATFORM

Main platform's features:

- Device registration
- Safe communications
- Specific DBs
- User rights mngt
- Data analytics
- Notification (SMS, push)
- Jobs (routines)

> 600 IoT platforms available

Pros (+):	Cons (-):
• Low start expenses (free limits, grants) • Scalable architecture • High reliability (tested on million devices) • Initial development could be quickly done by 3d party. Own development can be started later	• IoT platforms work in owner's data center (DC). Hard to build complete customer DC system • Major IoT platforms use DCs outside Russia (can't be used for B2G) • Cost is higher vs. rental of virtual machines (for high N of devices) • Hard to change to another platform (big code difference). But some APIs start to be standard

SELF-DEVELOPMENT of UPPER LEVEL SYSTEM

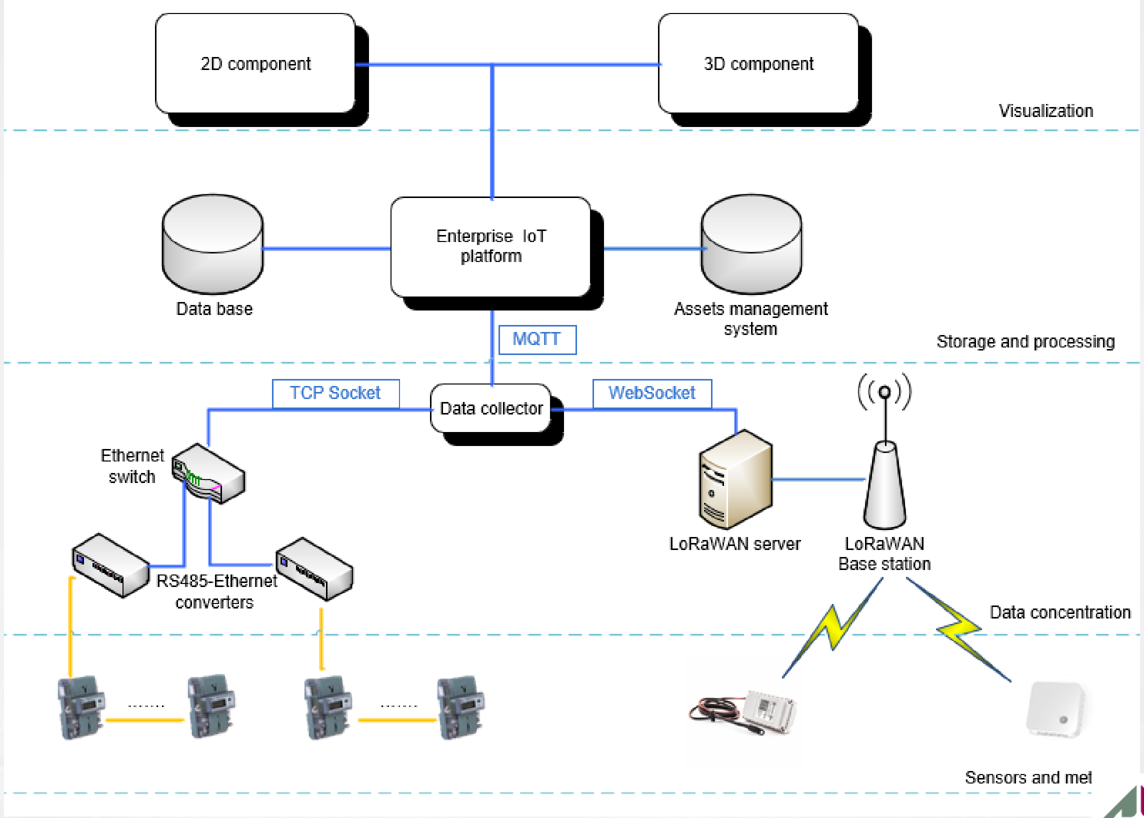
Possible protocols

WebSocket

MQTT

HTTP

Typical architecture



Possible tech stack

phpMyAdmin

ThingsBoard

cassandra

CMDBuild

node JS

LoRaWAN

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SELECTION STRATEGY

TECHNOLOGY SELECTION STRATEGY

Q: what to use to make optimal system for your case?

A: Use the following steps:

1. Define **system's parameters** (next slide)
2. Choose **connectivity techs** (suitable for implementation) → **list 1**
3. Choose **upper level system types** (suitable) → **list 2**
4. **Remove** obvious **outsiders** from **lists 1 & 2**
5. Make all possible **pairs** from lists 1 & 2 → **Relevant solutions.**
   Make **vectors** (CAPEX, OPEX, scalability, TB) from every pair
6. Find **optimal vector**, simple approaches are: min. cost of ownership or min. OPEX
   Make your system on technologies corresponding to **optimal vector**

TECH REQUIREMENTS ANALYSIS

Connectivity requirements

Parameter	Units
Number (N) of IoT devices	
N of messages from one device	msg/day
Mean device message size	bytes
Min. connection speed from device	bit/sec
Battery powered devices required	Yes/No
Connected to operator's network (GSM, GPON, Ethernet)	Yes/No
Can use IoT provider's network	Yes/No
Max. distance from device to HUB/coordinator	km
Type of business (TB) company's strategy for IoT business	0 - End user 1- Opertor

Upper level requirements

Parameters	Units
N of users	
Scaling coefficient (SC) (realistic plan in 2 yrs.) 1 - no future expansion 100 - max. expansion	times
Sources code are necessary	Yes/No
alarm delivery time to user (max.)	min

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ECONOMICAL PARAMETERS OF THE POSSIBLE SOLUTIONS

For each relevant solution estimate economical parameters (calculated for initial N of devices):

$$x=\{x_1,x_2...x_6\}$$

where x_1 - transport network cost, x_2 - upper-level system cost, x_3-integration cost; x_4-provider's infrastructure rent price; x_5-rent price for using upper-level functions (data processing), x_6- system maintenance cost.

And calculate CAPEX and OPEX:

$$CAPEX=x_1+x_2+x_3$$

$$OPEX=x_4+x_5+x_6$$

Form the vector of economical parameters for each solution:

$$P_i=\{CAPEX, OPEX, SC, TB\}$$

ECONOMIC PARAMETERS OPTIMIZATION

Choose the best in economic terms solution. It can be formulated as follow optimization problem:

$$\min (f(CAPEX_i, OPEX_i, SC, TB)), \text{ where } i \text{ - index of } i\text{-th possible solution}$$

How we can choose the function?

There are several reasonable variants of function definition. For example, you can target CAPEX minimization, OPEX minimization or cashflow with maximal flatness.

We propose to use the type of business parameter and scalability factor to define a weight of CAPEX and OPEX for particular application and business type:

$$\min (CAPEX_i/SC_i + OPEX_i * SC_i + OPEX_i * TB_i))$$

REAL WORLD EXAMPLES

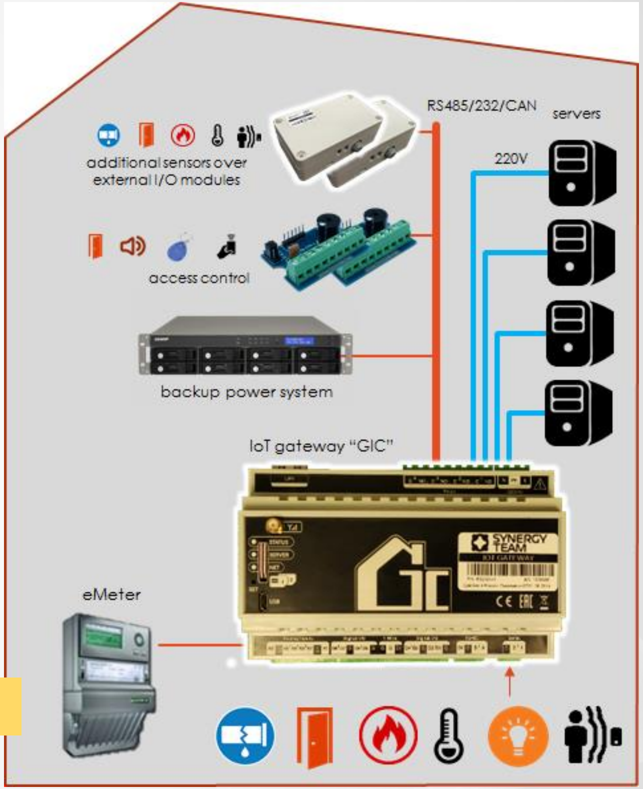
SERVER ROOMS MONITORING

Task:

- *4 server rooms, 2 telecom cabinets*
- *3 offices in the city with wired Internet*
- *Server's power control, on/off*
- *Battery (U, I, T), env. (T, H), fire, leakage control*
- *E-Meter values (P, U, I)*
- *Users: 3 admins, 2 managers*
- *No expansion planned*

Relevant solutions:

- *6 possible solutions*
- *Connectivity (all of Directly-connected IoT type):*
    - *2G cell*
    - *Ethernet*
    - *GPON*
- *Ready to use or cloud IoT upper level*



Suggested solution (finalist): Ethernet IoT gateway + SNMP NMS

More about case: www.synergy.msk.ru

ELECTRICAL MONITORING IN OFFICE BUILDING

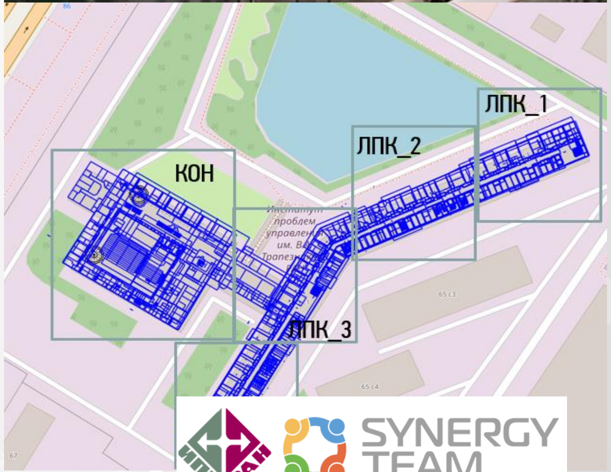
Task:

- *100 e-meters grouped ~20 pcs in 5 metering cabinets, in 1 office complex;*
- *Datasets collection for AI training (prediction);*
- *Intensive collection: 30 parameters (power, current, …) every 2 sec.*
- *Big data volume to be stored is about 100Gb/month;*
- *20 users;*
- *Plan to make market solution (operator's business)*

Relevant solutions:

- *3 possible solutions*
- *Connectivity:*
    - *NB-IoT / operator's HUB*
    - *PLC / private HUB*
    - *Ethernet / directly-connected*
- *Self-developed* upper level

Suggested solution: Ethernet bridges + self-developed upper level



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More about case: https://energy.ipu.ru/

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MEGAPOLIS HEAT METERING SYSTEM

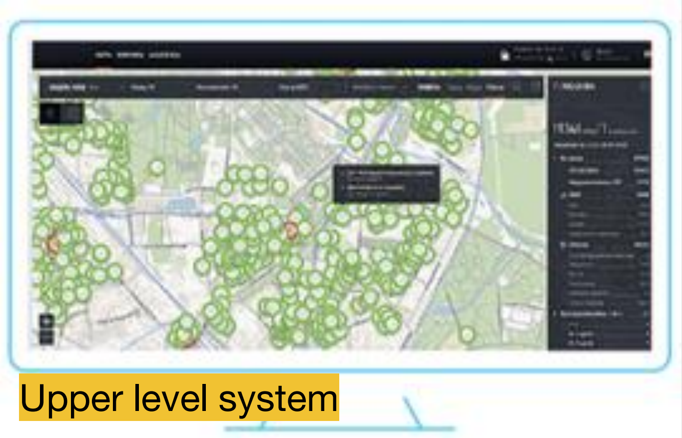
Task:

- *To optimize city heat consumption and lower citizen payments*
- *24.000+ buildings with data concentrators*
- *30.000+ heat meters (managed by municipal company)*
- *3.000+ users from major office, management comp., etc.*
- *Should work in city DC with 10+ 3d party systems*

Relevant solutions:

- *10 possible solutions*
- *Connectivity:*
  - *2G cell*
  - *NB-IoT/LoRa*
  - *Ethernet*
  - *GPON*
- *Ready to use or self-developed upper level*

Suggested solution: LoRaWAN+self-developed upper level system.



Upper level system

Data concentr.

Heat meters

More about case: https://asupr.mos.ru/

CASE STUDY SUMMARY

System description	Number of objects to be controlled and their type	N users	Optimal solution
Monitoring of the server rooms in the commercial company	6 rooms in 3 offices	5	Directly connected IoT (wired Ethernet), SNMP v.3 based NMS (Zabbix)
Monitoring of a car washes chain	10 car washes with 4 washing posts	5	Directly connected IoT (GSM gateways) System on cloud IoT platform (like AWS)
Office complex electricity monitoring system	100 power meters in office buildings	20	Private HUB connected IoT (RS-485 e-meters, Ethernet converters). Self-dev. system on ThingBoard, Postgres DB and integration layer.
Outdoor lighting controlling system in a large country side pansionat	100 street lighting poles with dimmable LED lamps	3	Operator's HUB connected IoT (LoRaWAN) Ready to use light management system / AMM
Megalopolis heat metering system (more than 10 roles, more than 10 integrations with other systems, strategic importance of data and management)	24K+ points (buildings) with different configuration	3K+	Directly connected IoT Self-dev. system, based on commercial and open source solutions, **Custom design field controllers (Ethernet+GSM)**

CUSTOM HW DEVELOPMENT OPTION

examples

Equipment cost can be up to 80% of the project cost
Custom HW dev. can cross it's payback thanks to lower cost of:

- equipment
- installation and tuning work

Factors making custom HW's price lower:

- standard case (housing) or no case (just PCB)
- minimal number of blocks, boards, cables, connectors
- use of modern SoC, <u>proven</u> asian brands (2d level)

Together with equipment Customer will also:

- Develop own brand
- Have additional instrument for tenders (functionality, price)
- Open new business direction

Custom HW development is reasonable if usually if objects N>200

CONCLUSION

Selection strategy of IoT management technology has been offered. Following simple ideas behind:

- For demo and small IoT projects better to use **serverless solutions** (direct IP / SMS)
- Use of **SCADA** is ideal for **industrial automation** and at complex energy facilities. For resource metering, network management, etc. use of **boxed SW products** is optimal (except for the cases below)
- Development on **IoT platform** is more difficult, but gives **more perspectives**. Use of **foreign** IoT platforms are seriously **limited in Russia**.
- The most difficult is **own development**. It is justified only **for government or very ambitious** projects
- **6 steps** routine offered
- If there are many objects of the same type, consider use of **custom designed equipment**

Points to be developed in the future:

- Transport reservation for applications where high reliability required
- Include new data transport types
- Offer different optimizations for different business (operator/user with own/credit money, user willing to become operator, etc.)
- Tariffs (operators, cloud services) and equipment cost database

CONTACTS

SYNERGY TEAM resources:

www.synergy.msk.ru
https://habr.com/ru/company/synergy/
https://asupr.mos.ru/

ICS RAS resources:

https://energy.ipu.ru/
https://www.ipu.ru/

E-mails:

l.karpenko@synergy.msk.ru
s.dushin@inbox.ru

THANK YOU