Intelligence at the Edge
Embracing the Data Flood
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IoT is about making decisions in the right place, at the right time and in time.
At the Edge

Network

Proximity
Edge is local

- Things / Edge things
- Local connectivity
- Edge gateways
- Backhaul Core Network
- Cloud

Local connectivity is local.
Many names similar concept

Mobile Edge Computing (ETSI)

Cloudlet (Carnegie Mellon University)

Fog computing (Cisco)

Micro datacenter (Microsoft)
Getting beyond the Edge

Edge things

Local connectivity

Edge gateways

Backhaul Core Network

Cloud
Edge evolving

Pattern recognition
Access point
Programming
Calls

Behaviors detection
Ecosystems applications
Self learning
What else? 😊
Example: Edge camera

Tokio metro, Kyobashi station
Suspicious behavior detection

Data at the Edge
Are not important, knowledge is!

Wisdom
Choosing objectives based on values

Knowledge
Ability to use information to achieve objectives

Information
Structure, meaning, context, importance

Data
Facts, figures, signals
**IoT is BIG**

**Gartner**

Table 1: Internet of Things Units Installed Base by Category (Millions of Units)

<table>
<thead>
<tr>
<th>Category</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer</td>
<td>2,277</td>
<td>3,023</td>
<td>4,024</td>
<td>13,509</td>
</tr>
<tr>
<td>Business: Cross-Industry</td>
<td>652</td>
<td>615</td>
<td>1,092</td>
<td>4,408</td>
</tr>
<tr>
<td>Business: Vertical-Specific</td>
<td>898</td>
<td>1,065</td>
<td>1,276</td>
<td>2,880</td>
</tr>
<tr>
<td>Grand Total</td>
<td>3,807</td>
<td>4,902</td>
<td>6,392</td>
<td>20,797</td>
</tr>
</tbody>
</table>

Source: Gartner (November 2015)

http://www.gartner.com/newsroom/id/3165317

**Juniper Research**

**Hampshire, 28th July:** New data from Juniper Research has revealed that the number of IoT (Internet of Things) connected devices will number 38.5 billion in 2020, up from 13.4 billion in 2015, a rise of over 285%.


**Cisco**

- World Population
  - 6.3 Billion
  - 6.8 Billion
  - 7.2 Billion
  - 7.6 Billion

- Connected Devices
  - 500 Million
  - 12.5 Billion
  - 25 Billion
  - 50 Billion

Source: Cisco IBSG, April 2011

How BIG?

In 2019 -> 507 ZB (507E+9 TB) data from IoT devices
[source: Global Cloud Index: Forecast and Methodology, 2014–2019]

SSD 1TB 2.5”

32 millions km [~20 millions miles]

light ray would need 1 min 45 sec
Manufacturing example

Metal bar manufacturing process
5 stages with very intense sampling
All machines storing data, single able to process it

Key here: data aggregation, filtering, anomaly detection, feedback loop for self adjustment
Manufacturing – connecting machines

All machines connected to data collector
- Connectivity
- Data processing engine
- Adapters
Manufacturing – handling data flow

Data filtering and aggregation
Pattern and trends/anomalies recognition
Additional input ERP etc
Cargo ship example

Limited communication capabilities (satellite)
Thousands of different containers to monitor
„Unstable” work conditions (weather, storm)

(Selected) data to analyze:
• Containers: inside and outside environment
• Ship: tilt/lean, vibration, ballast value
Data flooding the clouds

- Do we need all these data?
- How much to store? For how long?
- Ways to optimize? (more than tar.gz)
- What is volume/value relation?

<table>
<thead>
<tr>
<th>Absolutely!</th>
<th>No!</th>
</tr>
</thead>
<tbody>
<tr>
<td>All!</td>
<td>What for?</td>
</tr>
<tr>
<td>What is “tar.gz”?</td>
<td>Hmmn…</td>
</tr>
<tr>
<td>More is more!</td>
<td>Less is more!</td>
</tr>
</tbody>
</table>

To be continued
Data flooding clouds... really?

...true, but most of data will never go beyond Edge
Intelligent edge
Intelligence is a freedom of choice

A smart machine will first consider which is more worth its while: to perform the given task or, instead, to figure some way out of it.

Whichever is easier.
And why indeed should it behave otherwise, being truly intelligent? For true intelligence demands choice, internal freedom

Stanislaw LEM „The Futurological Congress (1971)
Building knowledge at the Edge

Old school

Data → Information → Knowledge

Intelligent Edge

Data → Information → Knowledge
Why Edge/ Fog computing

- Proximity to the source of data
- Lower latency - speedup of decision making time
- Reduced global bandwidth
- Local context, local security
- Ownership of data, privacy protection
Handling data at the Edge

Building knowledge (analytics, patterns, trends, co-relations, rules) → Taking local decisions → Sharing knowledge with clouds and with other edges → Evolving (feedback loop, new data, knowledge from outside)

Handling data at the Edge
Learning / building knowledge

Goal: learn rather than follow instructions
• find patterns
• verify/ filter data
• predict or best-guess
• decide
• get feedback and adjust

Modeling learning: behavior trees, neural networks, genetic algorithms,…
Selecting AI for the Edge

Resources constraints
Type of problem (optimization, pattern recognition)
Regression analysis
Adjustment possibility
Derivatives known?
Patterns known?
Amount of input data
Learning time

http://www.craft.ai/blog/NEST-like/
Wrap up
Data processing and analysis close to the source
Critical especially when privacy, time or transmission matters
AI key to handle, classify and analyze big flows (flood)
Thank you

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