Heroes – Think Digital
Case study: Integrating IoT in your maintenance practice

Werner Vink | Engineer IoT
Mission
Think Digital

Vision
Coach companies to become Digital winners. Scout and Build smart digital solutions.
Market Prospects 2025

Internet of Things

- **Machinery**: Connected machines for real-time monitoring
- **Building Management**: Creating smart buildings/cities
- **Healthcare**: Remote monitoring of patients health
- **Logistics**: Precise location services for tracking and trace
- **Devices**: Management and control applications
- **Retail**: Insights about shopping behaviour

- **4 BILLION**
  - Connected people
- **$4 TRILLION**
  - Yearly revenue opportunities
- **25+ MILLION**
  - Apps
- **25+ BILLION**
  - Embedded and intelligent systems
- **25+ TRILLION**
  - GB’s of data

*Source: Mckinsey 2016*
Where is the value potential?

Internet of Things

Interoperability required to capture **40% of total value**

< 1 % of data currently used, mostly for alarms or real-time control; more can be used for optimization and prediction

**2 x more value** from B2B applications than consumer

*Source: Mckinsey 2016*

- Developing world: 40%
- Developed world: 60%
B2B Opportunities

Internet of Things

Use cases that will enhance the process of management in regard to the total cost of ownership

- Enhancing efficiency
  - e.g. optimizing use of energy
- Quality control
  - e.g. reducing physical inspections
- Predicting and avoiding
  - e.g. reducing downtime risk
- Asset tracking
  - e.g. alarms using geofencing
- Inventory management
  - e.g. real-time status
- Supply chain
  - e.g. schedule tweaking
Technology Value Chain

Internet of Things
Internet of Things
A world connected

Use Case #1
Predictive Maintenance
Cutting out operational inefficiencies
Predictive Maintenance

Internet of Things

• Sustainable System Maintenance
  • Enabling machine learning to predict system behaviour
  • Stimulates data-driven decision-making
  • Improve asset lifespan and utilization

• Value Proposition
  • Improve maintenance effectiveness
  • Increasing system operational efficiency
  • More flexibility in maintenance planning
Predictive Maintenance

Internet of Things

- Replacing filter in air handling unit (AHU)
  - Step 1: What is the preferred moment of replacement?
  - Step 2: Which data is available that says something about the filter?
  - Step 3: Which theoretical background has this data?
  - Step 4: From the data, can a model be obtained that predicts filter behaviour?
Predictive Maintenance

Internet of Things

• Step 1: What is the preferred moment of replacement?
  • According manufacturer 10,920 hours of operations (+/- 65 weeks)
Predictive Maintenance

Internet of Things

• **Step 2:** Which data is available that says something about the filter?

![Graph showing Supply Air Filter Pressure in function of Weeks]

- **First period** (26 weeks)
- **Second period** (23 weeks)
Predictive Maintenance

Internet of Things

• Step 3: Which theoretical background has this data?
  • At a constant debit and volume the pollution of a filter can be described according the law of Boucher’s

\[
\log\left(\frac{P}{P_i}\right) = -J \cdot V_L
\]

\[
P(t) = c_0 + c_1 \cdot e^{J \cdot V \cdot t}
\]

\(P\) [Pa] = pressure over filter on time \(x\)

\(P_i\) [Pa] = initial pressure when clean

\(J\) [-] = Boucher’s ratio of filter pore blocking

\(V_L\) [m³] = Volume of air passing

\(C_0\) [Pa] = initial pressure of the clean filter clean

\(C_1\) [-] = Constant to determine

\(J\) [-] = Boucher’s ratio of filter pore blocking
Predictive Maintenance

Internet of Things

• Step 4: Can a model be obtained from the data to predict filter behaviour?

  • Through 2th order polynomial regression an average model is obtained over both data periods.

  • First period (blue line):
    R-square = 90%

  • Second period (red line):
    R-square = 85%

  • Average regression function (black line):
    \[ P(t) = P_i + 2e^{0.08t} \]

Prediction: +/- 8.900 hours (53 weeks)
250 Pa is reached.
Predictive Maintenance

Internet of Things

• Conclusions
  • Filter needs to be replaced around 250Pa.
  • Current filter replacement at +/- 4.000 hours (80-90 Pa)
  • Model predicts 250Pa is reached at +/- 8.900 hours of operation.

• Recommendations
  • Dataset contains P < 100Pa. Extending the dataset with P > 100 Pa gives outcome in obtaining a more accurate model
  • Current replacement cycle can be optimized from 2 times to 1 time per year
  • Prediction gives outcome to increase flexibility in maintenance planning
Use Case #2
Semantic Data Modelling
Making your data future proof
Semantic Data Modelling

Internet of Things

• Workload in a typical IoT project
  • 60% time spend on data extraction and understanding
  • 30% time spend on performing value added analytics

• Value Proposition
  • Bringing down the 60% spend on data extraction and understanding
  • Focus on what matters: creating valuable analytics
Semantic Data Modelling

Internet of Things

• Data from control systems and IoT devices
  • Lack of uniformity in naming the data
  • Lack on control system documentation

It’s a maze out there!!!!!
Semantic Data Modelling

Internet of Things

• At Heroes we work according Haystack
  • Open Source initiative from Virginia, USA (2014)
  • Fast growing world wide community
  • Sponsors: Intel, Siemens, KNX, Tridium, Arup

• How does it work?
  • Adding extra (meta) data using predefined tags
  • Comparable with the # of social media

• Why?
  • Shortens the analysis time
  • Simplifies the scaling of algorithms
  • Broad integration possibilities: *i.e.* Python, Node.JS, C++, C#, Java

Historical Data + TAG TAG TAG = Scalable Analytics
Semantic Data Modelling

Internet of Things

• **Equips**
  - Heat pumps
  - Heat Exchangers
  - Gas-fired boilers
  - Chillers
  - Etc.

• **Points**
  - Sensors
  - Set points
  - Control signals
Semantic Data Modelling

Internet of Things

Equip tags: ahu, hvac, equip

Point tags: outside air temp sensor point

Point tags: outside air filter delta pressure sensor point

Point tags: heatWheel cmd point

Point tags: return water valve cmd point

Point tags: return water temp Sensor point

Point tags: return / discharge air temp sensor point
Semantic Data Modelling

Internet of Things

Total 15 AHUs

216 points

Relevant for 8 AHUs, directly in one overview
Semantic Data Modelling

Internet of Things

• Advantages of Semantic Data Modelling
  • Structured database; effective queries
  • Decreases labour intensity of analytics
  • Eases the scalability of algorithms and analytics

• Advantages of Project Haystack principles
  • Predefined tags for different data sources
  • Fast growing open source community
  • Actively sharing ideas and code
Internet of Things
A world connected

Getting started with IoT
Exploring your business opportunities
What is your current practice?

Internet of Things

**Connected**

Imagine if you could instantly access data from facilities anywhere in the world and make mission-critical decisions more intelligently than ever before.

**Remote Monitoring**

Imagine that within your connected facilities thousand of devices are monitored and no/less physical inspection is needed.

**Predictive Analytics**

Imagine that your remote monitoring could automatically identify and fix potential problems before they happen.
Dare to start, but start wisely

Internet of Things

- Explore IoT opportunities
- Idea analysis & prioritization
- Build your IoT practice
- Get executive support
- Secure your first IoT PoC
- Grow your IoT practice

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