From Big Data to Smart Data
Thomas Hahn
The Evolution of Big Data

~1960

- Digital data collection
- First databases

~1986

- Data warehousing
- Data cubes
- Relational databases
- Financial data

~1993

- Data Mining
- Statistics
- Artificial intelligence
- Machine learning
- Unstructured data

~2015

- Big data analytics
- Stream processing
- Massively distributed
- NoSQL databases
- Heterogeneous data and knowledge
- Petabytes of data
Big Data Analytics is key for protecting and extending existing businesses and creating new services

Technology push

- Proliferation of **smart sensors, smart devices, apps and Internet of Things** leading to data volume doubling every two years
- Combination of data analytics with system and sensor understanding enables complex decision support embedded into operational processes

- New SW and HW architectures enabling **massive data processing**

---

NoSQL databases
- cloud deployment
- massively distributed computing
- Redis
- riak
- MongoDB
- Cassandra

![Graph showing data growth](image)
Big Data Analytics is key for protecting and extending existing businesses and creating new services

**Market pull**

- Rising **customer expectations**
- **IT players** moving into Siemens home turf
- Competitors’ **M&As** yielding **tangible offerings**
- Data analytics technologies **enables** optimized **service business** and will **differentiate our Siemens systems and solutions**
- **New business models** (e.g. DaaS) and **eco-systems**

© Siemens AG 2014. All rights reserved.
Focus of data analytics is changing: From description of past to decision support

Value and Complexity

Inform

- Descriptive
  - What happened?

Analyze

- Diagnostic
  - Why did it happen?

Act

- Predictive
  - What will happen?

- Prescriptive
  - What shall we do?

Examples

- Descriptive
  - Plant operation report
  - Fault report

- Diagnostic
  - Alarm management
  - Root cause identification

- Predictive
  - Power consumption prediction
  - Fault prediction

- Prescriptive
  - Operation point optimization
  - Load balancing

Current penetration across all industries (according to Gartner 2013)

- 99% Adopt by vast majority but not all data
- 30% Adopted by minorities
- 13% Still few adopters
- 3% Very few early adopters
**Smart data to business principle:** Combination of domain, device and analytics know-how

**Data from Siemens‘ Products and Solutions**

- **Domain data**
- **Data**
- **Data analytics**
- **Business Intelligence**
- **Business Innovation**
- **Value Generation**

**Customer benefit**
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security

**E.g. Power plants**
**E.g. Power grids**
**E.g. Factories**
**E.g. Hospitals**

**Domain know-how** + **Device know-how** + **Analytics know-how** = **Smart Data**
Smart data to business example (1/9):
Optimization of gas turbine operation

Results
• Reduced NOx Emissions
• Extension of service intervals

Energy system
• Market drivers
• Customer needs
• Product cycles

Gas turbines
• Mechanical Engineering
• Thermodynamics
• Combustion chemistry
• Sensor properties

Autonomous Learning
• Neural Networks
• Smart Data Architecture processes data from 5000 sensors per sec.

Domain know-how + Device know-how + Analytics know-how = Smart Data
Smart data to business example (2/9): Service intelligence for gas turbine fleet

Energy system
- Market drivers
- Customer needs
- Product cycles

Gas turbines
- Mechanical Engineering
- Thermodynamics
- Combustion chemistry
- Sensor properties

Service analytics
- Integration of more than 30 data sources
- Six millions records per day

Results
- Faster outage planning
- Faster issue resolution
- Improved forecast of service events

Domain know-how + Device know-how + Analytics know-how = Smart Data
Smart data to business example (3/9):
Optimization of wind parks (Project ALICE, CeBIT)

Wind power
- Market drivers
- Customer needs
- Aerodynamics
- Meteorologics

Wind turbines
- ~12,000 installed
- Mechanical Engineering
- Sensor properties
- Controller design

Autonomous Learning
- Neural Networks
- Robust policy generation despite very noisy data

Results
- 1% increase of annual energy with optimized control policy

\[
\text{target} = r_t
\]

\[
\tanh
\]

\[
1 - \gamma
\]

Domain know-how + Device know-how + Analytics know-how = Smart Data
Smart data to business example (4/9): Health check for CERN’s Large Hadron Collider

Results
- Early warnings to increase Operating Hours

Automation infrastructure
- Market leader in industry automation
- Strong presence in all business areas

Autom. components
- Complex: hundreds of SCADA systems and SIMATIC control systems

Rule and pattern mining
- >1 terabyte of operational data generated per day
- Detect fault patterns

Domain know-how + Device know-how + Analytics know-how = Smart Data
Smart data to business example (5/9):
Image-guided diagnosis and therapy for heart valves

**Healthcare Ecosystem**
- Cost / effectiveness
- Accurate diagnosis / therapy
- Less invasive surgery

**Imaging Scanners**
- Robotic imaging
- Interventional imaging
- Low radiation
- Reconstruction & fusion

**Machine Learning**
- Image databases
- Fast machine learning
- Identify relevant structures

**Results**
- Industry wide unique feature that automates workflow and guides the surgeon
- Applied to thousands of valve implants
- Next generation in the pipeline

**Domain know-how** + **Device know-how** + **Analytics know-how** = **Smart Data**
**Smart data to business example (6/9): Smart City Research Aspern, Vienna**

**Objective**

“My clear goal now is to become the greenest city in the world.”

Michael Häupl, Mayor of Vienna

<table>
<thead>
<tr>
<th>City infrastructure</th>
<th>Smart Grid / Smart building</th>
<th>Smart City Cockpit</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Market drivers</td>
<td>• Electrical engineering</td>
<td>• Integration of smart grid, smart buildings, water and mobility</td>
</tr>
<tr>
<td>• Customer needs</td>
<td>• Power storage</td>
<td>• Analytics dashboard</td>
</tr>
<tr>
<td>• Power networks</td>
<td>• Smart meters</td>
<td></td>
</tr>
<tr>
<td>• Building technology</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Joint Investment City of Vienna/Siemens:** Close to € 40 mil.

**Domain know-how + Device know-how + Analytics know-how = Smart Data**
Smart data to business example (7/9): Procurement and Trading based on Neural Network Forecasts

Economics
- Commodity market and commodity prices
- Market Behavior
- Financials

Computer cluster
- Operation/ Utilization of Multicore CPU Clusters (500+ cores)
- Multicore computing

Econometrics w/ neural nets
- Time Series Data Management
- Modeling and Analysis

Results
- Predict commodity prices for optimal procurement decisions and trading
- Prescriptive: Decision support based on expectation and risk

Domain know-how + Device know-how + Analytics know-how = Smart Data
Smart data to business example (8/9): Condition Monitoring for Water Supply Networks

<table>
<thead>
<tr>
<th>Levee Building</th>
<th>Levee Sensors</th>
<th>Neural Networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hydrology</td>
<td>• Pressure</td>
<td>• Time Series Data Management</td>
</tr>
<tr>
<td>• Geology</td>
<td>• Temperature</td>
<td>• Anomaly detection (Slipping)</td>
</tr>
<tr>
<td>• Weather Forecasting</td>
<td>• Geometrical deviation</td>
<td></td>
</tr>
</tbody>
</table>

**Results**

- “Effectiveness of levee reinforcement has to be increased by a factor 4 which is impossible without innovation.”
  Peter Jansen, Waternet

© Siemens AG 2014. All rights reserved.

Page 14  2014-04-07  Thomas Hahn
Smart data to business example (9/9): Advanced Traffic Forecast from Floating Car Data

Traffic Management
- Traffic Flow Models
- Traffic Planning

Traffic Sensors
- Induction Loops (traffic lights and guidance systems)
- GPS and Car Data

Neural Networks
- Time Series Data
- Traffic Forecasting
- Optimization of Traffic Flow

Objective
- Highly accurate traffic forecast
- Improve short-term traffic prediction by combining data sources

Domain know-how + Device know-how + Analytics know-how = Smart Data

© Siemens AG 2014. All rights reserved.
# Smart data to business examples: Lessons learned

For all use cases/business cases the data value stream needs to be specifically designed or adapted due to varying data types, data amount, data quality, data sources, data models …

⇒ "One-size-doesn’t-fit-all"

Based on today’s technologies the combination of analytics know how and application know how can generate new business and value add (Smart data to business examples 1–9)

To create new business, new technologies need to be developed e.g. in the areas of multicore computing and cloud computing, but also new mathematics for analytics are necessary (artificial intelligence, neural networks …)

The combination of different data from different data sources (e.g. customer data + Siemens data) and their common analysis leads to advantages for both partners e.g. floating car data combined with Siemens traffic management systems data

Security and data protection need to be integral part of all technical solutions along the data value chain (data value stream)
Smart Data Innovation Lab: Siemens and Fraunhofer jointly leading the Smart Cities Working Group

Data Innovation Communities

- Industrie 4.0
- Energie
- Smart Cities
- Medizin

Arbeitsgruppe Data Curation

Arbeitsgruppe Recht

Betrieb – Plattform & Werkzeuge

© Siemens AG 2014. All rights reserved.
Smart data to business outlook: The way to an ecosystem partner framework

Data value stream based on Siemens' Products and Solutions

Domain data

Installed products & systems, processes, sensor data

"Smart data to business"

Data analytics

Business Intelligence

Business Innovation

Value Generation

Customer benefit
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security

Data value stream based on Ecosystem partner’s Products and Solutions

Domain data

Installed products & systems, processes, sensor data

"Smart data to business"

Data analytics

Business Intelligence

Business Innovation

Value Generation

Customer benefit
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security
Smart data to business outlook:
The way to an ecosystem partner framework
Sharing Data & Algorithms

Data value stream based on Siemens' Products and Solutions

Customer benefit
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security

Domain data
- "Smart data to business"
- Data
- Data analytics
- Business Intelligence
- Business Innovation
- Value Generation

Data
- Installed products & systems, processes, sensor data

Data analytics
- Domain data
- "Smart data to business"

Business Intelligence
- Value Generation

Business Innovation
- Value Generation

Value Generation
- Customer benefit
  - Performance increase
  - Energy saving
  - Cost reduction
  - Risk avoidance / security

Ecosystem partner’s Products and Solutions

Customer benefit
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security

Domain data
- "Smart data to business"
- Data
- Data analytics
- Business Intelligence
- Business Innovation
- Value Generation

Data
- Installed products & systems, processes, sensor data

Data analytics
- Domain data
- "Smart data to business"
Smart data to business outlook: The way to an ecosystem partner framework: Using an unified Data Analytics Framework

Features
- Modular and service-oriented
- Workflow-based
- Multiple operation modes
- Cloud (public, private, hybrid)
- On-premise
- Integrated security
- Protection of data at rest and in transit, during the whole lifecycle
- Protection of algorithms / models
- Compliance to industry standards

Data Analytics Framework

Customer

Value Generation

Data Business
Innovation

Domain data
```
Smart data to business```

Installed products & systems, processes, sensor data

Data analytics

Workflow management

IT Infrastructure

Features
- Modular and service-oriented
- Workflow-based
- Multiple operation modes
- Cloud (public, private, hybrid)
- On-premise
- Integrated security
- Protection of data at rest and in transit, during the whole lifecycle
- Protection of algorithms / models
- Compliance to industry standards

Data Analytics Framework

Data Integration

Data Management

Data Modeling & Analysis

Data Presentation

Communication

Security

Operations Management

Workflow management

IT Infrastructure

Features
- Modular and service-oriented
- Workflow-based
- Multiple operation modes
- Cloud (public, private, hybrid)
- On-premise
- Integrated security
- Protection of data at rest and in transit, during the whole lifecycle
- Protection of algorithms / models
- Compliance to industry standards

Data Analytics Framework

Data Integration

Data Management

Data Modeling & Analysis

Data Presentation

Communication

Security

Operations Management

Workflow management

IT Infrastructure
Smart data to business outlook: The way to an ecosystem partner framework: IT security architecture with world class reliability required

Data value stream based on Siemens’ Products and Solutions

Customer benefit
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security

Customer benefit
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security

Domain data

Installed products & systems, processes, sensor data

Data

Data analytics

Business Intelligence

Business Innovation

Value Generation

Data

Algorithms

Value Generation

Value Generation

Installed products & systems, processes, sensor data

Data

Data analytics

Business Intelligence

Business Innovation

Value Generation

Customer benefit
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security

Customer benefit
- Performance increase
- Energy saving
- Cost reduction
- Risk avoidance / security

Domain data

"Smart data to business"

Data value stream based on Ecosystem partner’s Products and Solutions

© Siemens AG 2014. All rights reserved.

Page 21

2014-04-07

Thomas Hahn
Smart data to business outlook: The way to an ecosystem partner framework: Cloud based architectures to be developed

Data value stream based on Siemens‘ Products and Solutions

Domain data

Installed products & systems, processes, sensor data

Data

Data analytics

Business Intelligence

Business Innovation

Value Generation

"Smart data to business"

Customer benefit
• Performance increase
• Energy saving
• Cost reduction
• Risk avoidance / security

Data

Algorithms

Data

Business Intelligence

Business Innovation

Value Generation

"Smart data to business"

Customer benefit
• Performance increase
• Energy saving
• Cost reduction
• Risk avoidance / security

Data value stream based on Ecosystem partner’s Products and Solutions

Domain data

Installed products & systems, processes, sensor data

Value Generation

Customers benefit
• Performance increase
• Energy saving
• Cost reduction
• Risk avoidance / security

© Siemens AG 2014. All rights reserved.

Page 22

2014-04-07

Thomas Hahn
Smart data to business requires the collaboration of researchers, scientists and specialists from different areas with different competencies

<table>
<thead>
<tr>
<th>Area</th>
<th>Competencies/ Know how</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Science</td>
<td>• Machine Learning&lt;br&gt;• Database Theory&lt;br&gt;• Software Engineering</td>
</tr>
<tr>
<td>Mathematics &amp; Statistics</td>
<td>• Numerical Mathematics&lt;br&gt;• Statistics&lt;br&gt;• Optimization (discrete, continuously, dynamic …)</td>
</tr>
<tr>
<td>Physics &amp; Engineering</td>
<td>• Communications engineering&lt;br&gt;• Control engineering&lt;br&gt;• Automation engineering&lt;br&gt;• E.g. Mechanics&lt;br&gt;• Fluid mechanics&lt;br&gt;• Experimental physics</td>
</tr>
<tr>
<td>Economics</td>
<td>• Econometrics&lt;br&gt;• Finances&lt;br&gt;• Business Science</td>
</tr>
</tbody>
</table>
Leveraging Business opportunities via Smart Data Ecosystems

We make Smart Data a reality
Creating a data analytics ecosystem with strong partners to enhance business value.

Thank you for your attention.
Thank you!
Many thanks for your attention!

Thomas Hahn
Chief Key Expert Engineer
Siemens AG / Germany / CT RTC CES
Günther-Scharowsky-Straße 1
91058 Erlangen
Phone: +49 (9131) 7-23912
Fax: +49 (89) 636-34098
Mobile: +49 (172) 8352610
E-mail: hahn.th@siemens.com
siemens.com/innovation