The Internet of Manufacturing Things

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The Internet of Things

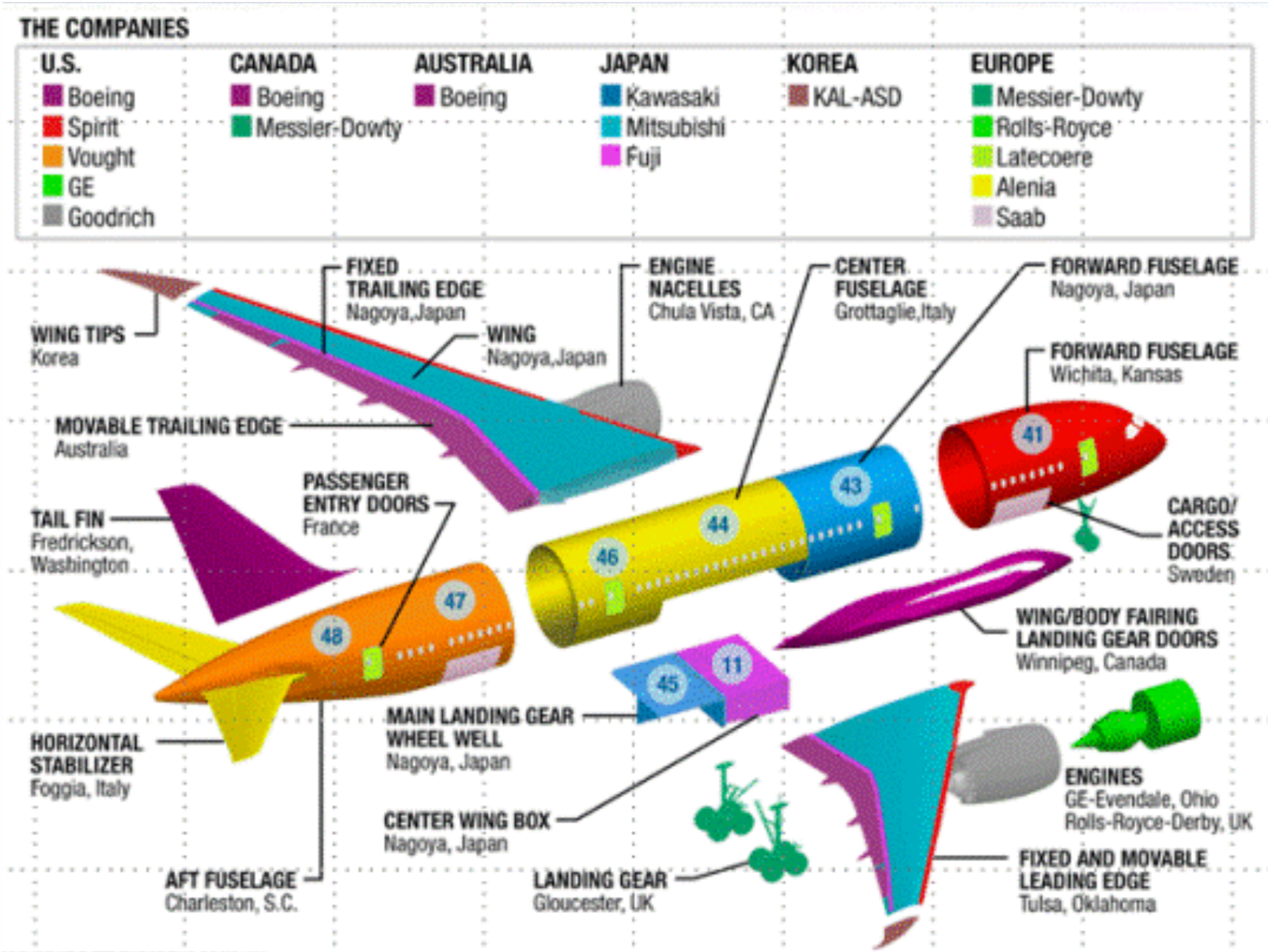
"interconnection of sensors, devices, and other *things*"

Why Manufacturing?

- Manufacturing is Big: $2 Trillion sector
- Discrete Manufacturing: Products for consumers and the supply chain
- High potential for productivity improvement
- Manufacturing generates a very large amount of data – most of it falls on the floor

Manufacturing Today

- Global
- Fragmented
- Heterogeneous

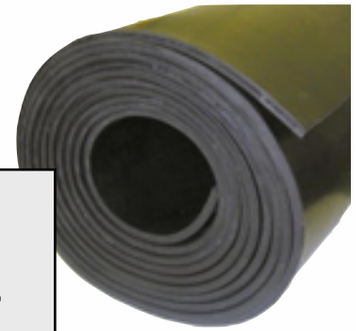


Improving the Transformation

- Productivity? Profitability?
  Return on asset?

- Part quality? Employee safety?
  Product reliability?

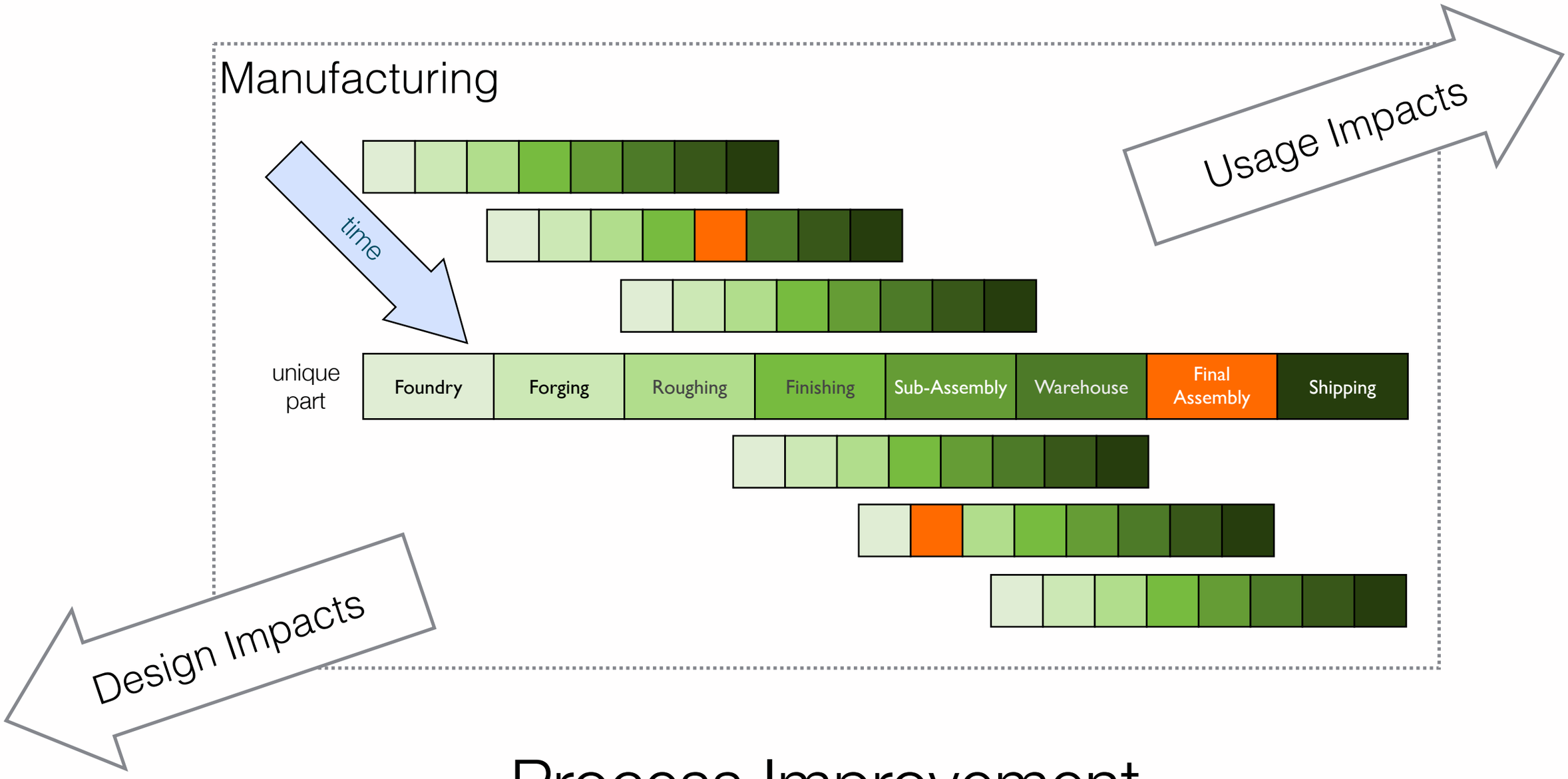
- Sustainability? Energy usage?
  Pollution?



transformation

Grand Challenge: Process Traceability

Track flow of resources and intelligence across manufacturing process



Process Improvement
Design Integration
Usage Analytics

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Manufacturing in the Frontiers

Solving the Grand Challenge

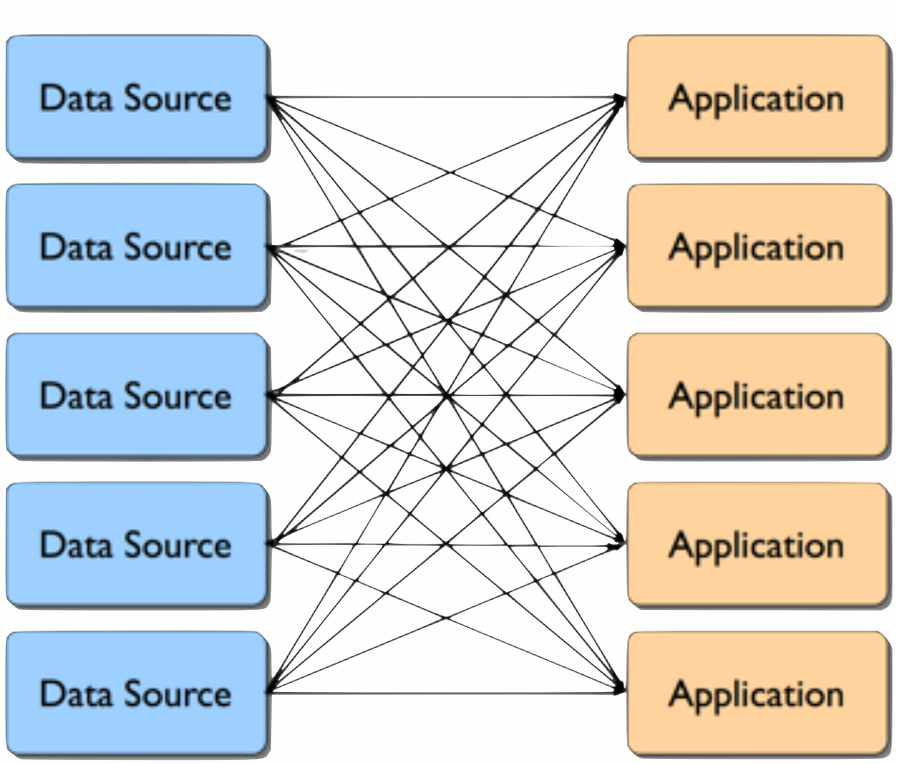
Standards

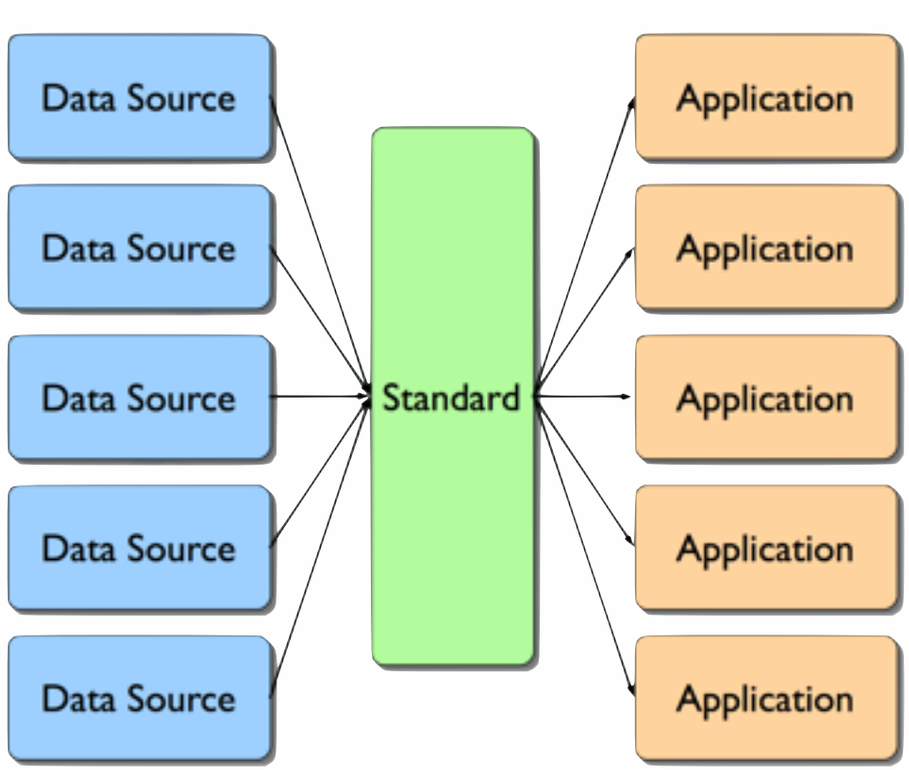
Sensors

Software

Standards

- Manufacturing data highly complex
- Specialized technical knowledge deterrent to innovation





What do you prefer?

MTConnect

- Open royalty-free standard providing data from devices using a common unambiguous vocabulary
- Uses XML and HTTP – Internet ready
- Simple, free, and extensible
- Design Goals
  - Capture manufacturing domain model
  - Read-only – inherently secure

Sensors

- Enable decision-making and automation
- Sensors at every level:
  - Manufacturing process —> Supply Chain
- What we need:
  - Minimally Invasive
  - Physics based
- Open question: Where do you put the intelligence?

Sensor Intelligence

- Traditional Approach: Self-contained local command-and-control loops
- Is centralized intelligence possible?
- Challenges: data load, bandwidth, latency
- Solution:
  - Distributed decentralized systems
  - Split decisions between local and central controllers

Software

- Data Management:
  - High data volumes
  - Structured and unstructured data
- Decision-making:
  - Event-based decision making
  - Multi-dimensional reasoning
  - Multiple temporal scales

Data Volumes

Small Shop: 2~10 TB/year

Medium Shop: 5 ~ 25 TB/year

Large Shop: 16 ~ 80 TB/year

Enterprise: 80 ~ 5000 TB/year

US Machining Sector: 200 PB ~ 1XB/year

Data Types

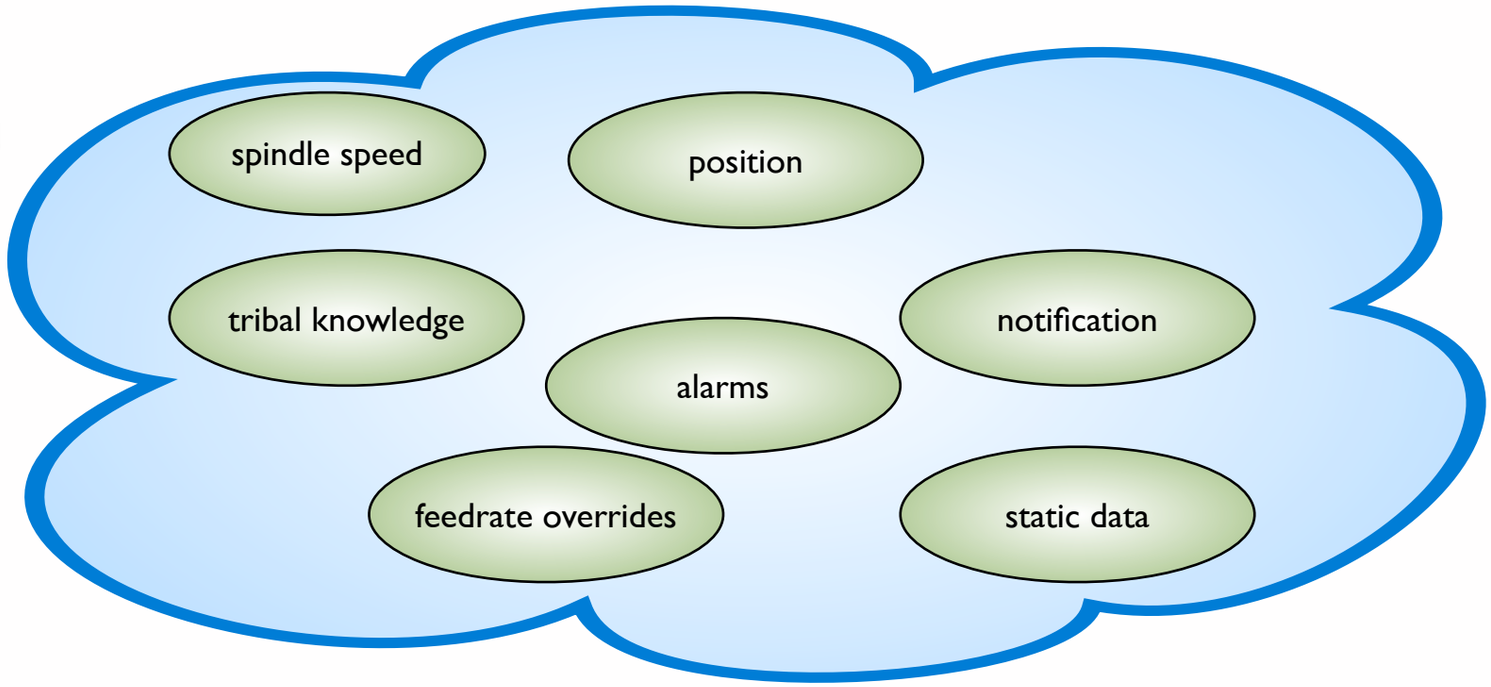
Structured	Unstructured	Tribal Knowledge
Sensor Machine Telemetrics	Alarms, Faults Quality Control Performance + Test	Annotations Over-rides Interruptions

So what do we do with all of this data?

Event Reasoning

Event: Something that happened at a point in time

The Manufacturing Event Cloud



Event Processing

fusion

filter

aggregate

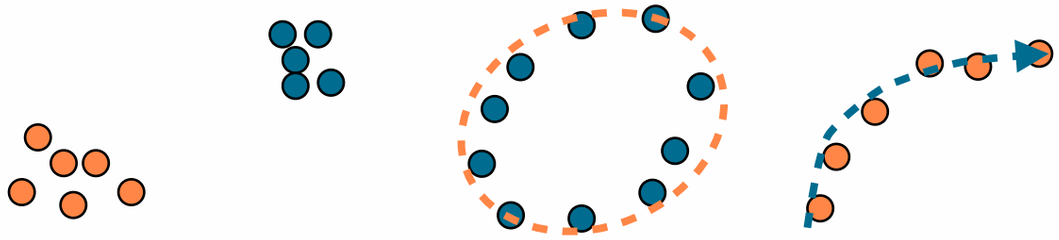
identify relationships

Complex Event Processing

Temporal

Overlap | Before/After | Contains

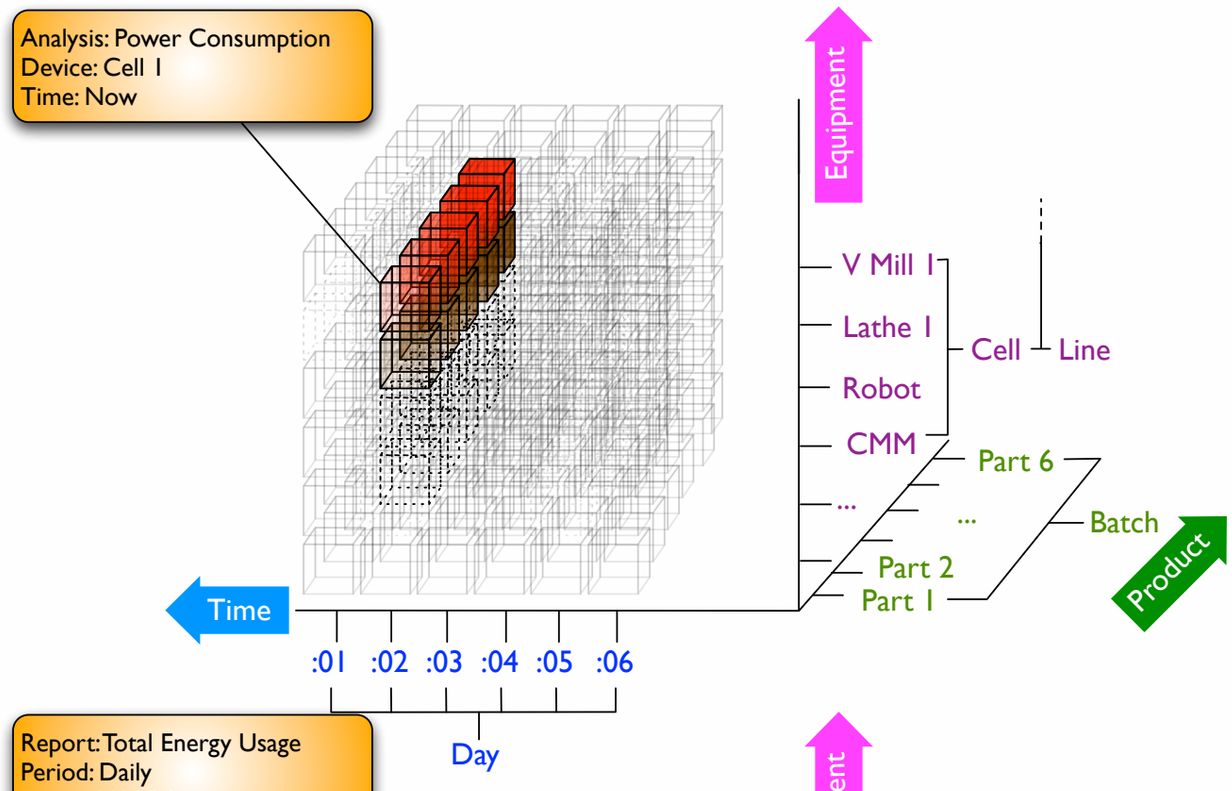
Spatial

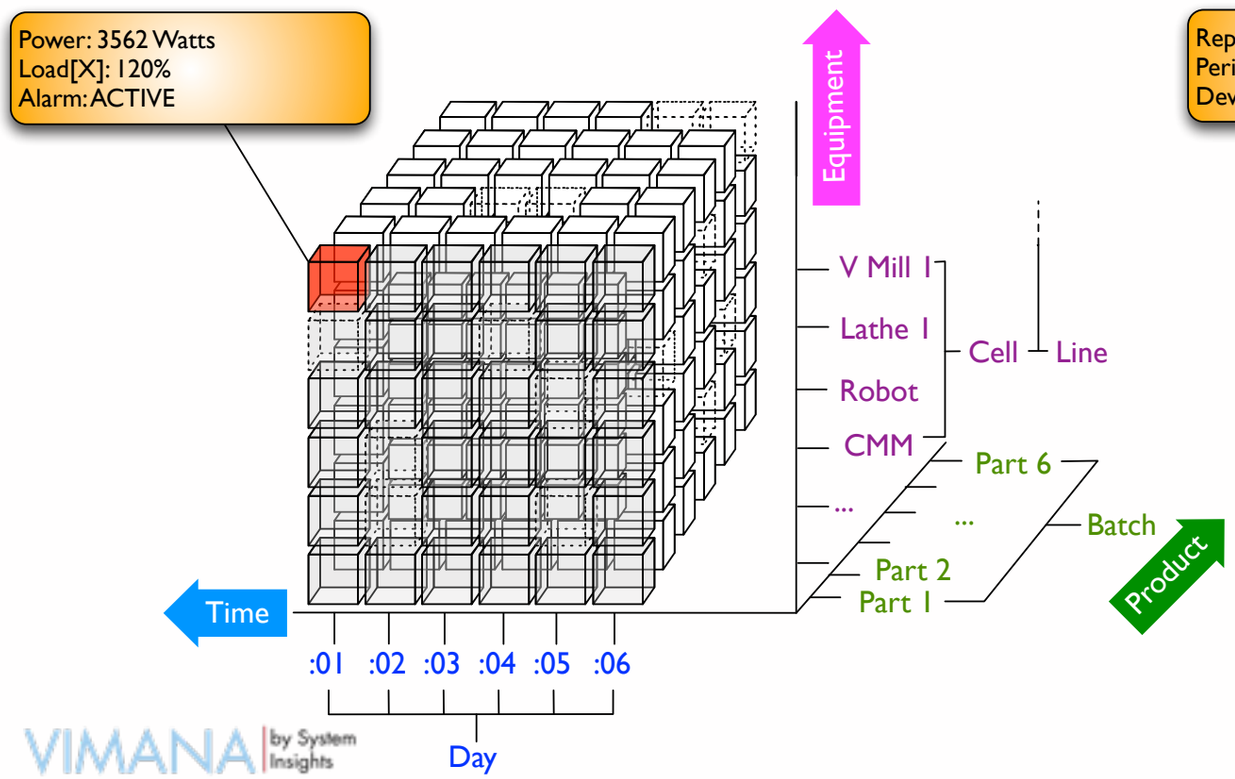


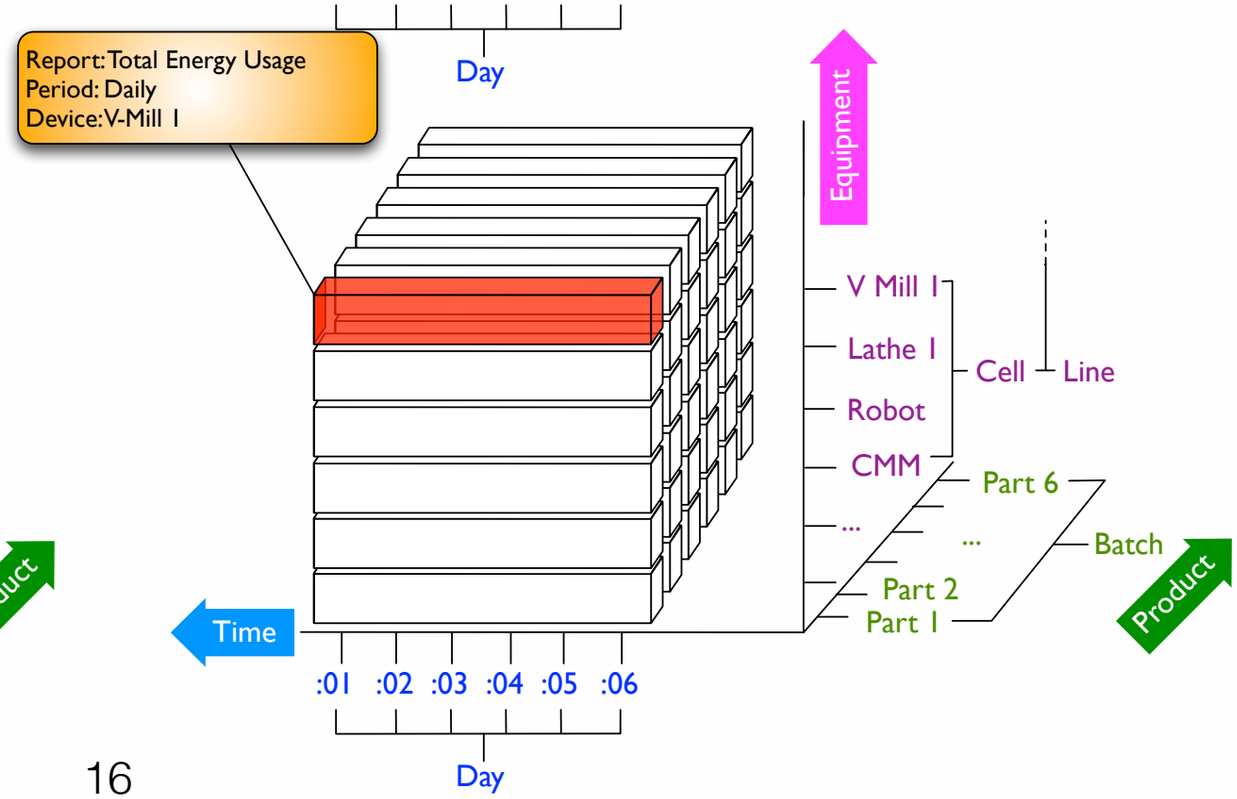
Clustering | Shapes | Trending

Multidimensional Reasoning

Multi-dimensional reasoning allows us to slice data across any plane, including: time, machine organization, parts







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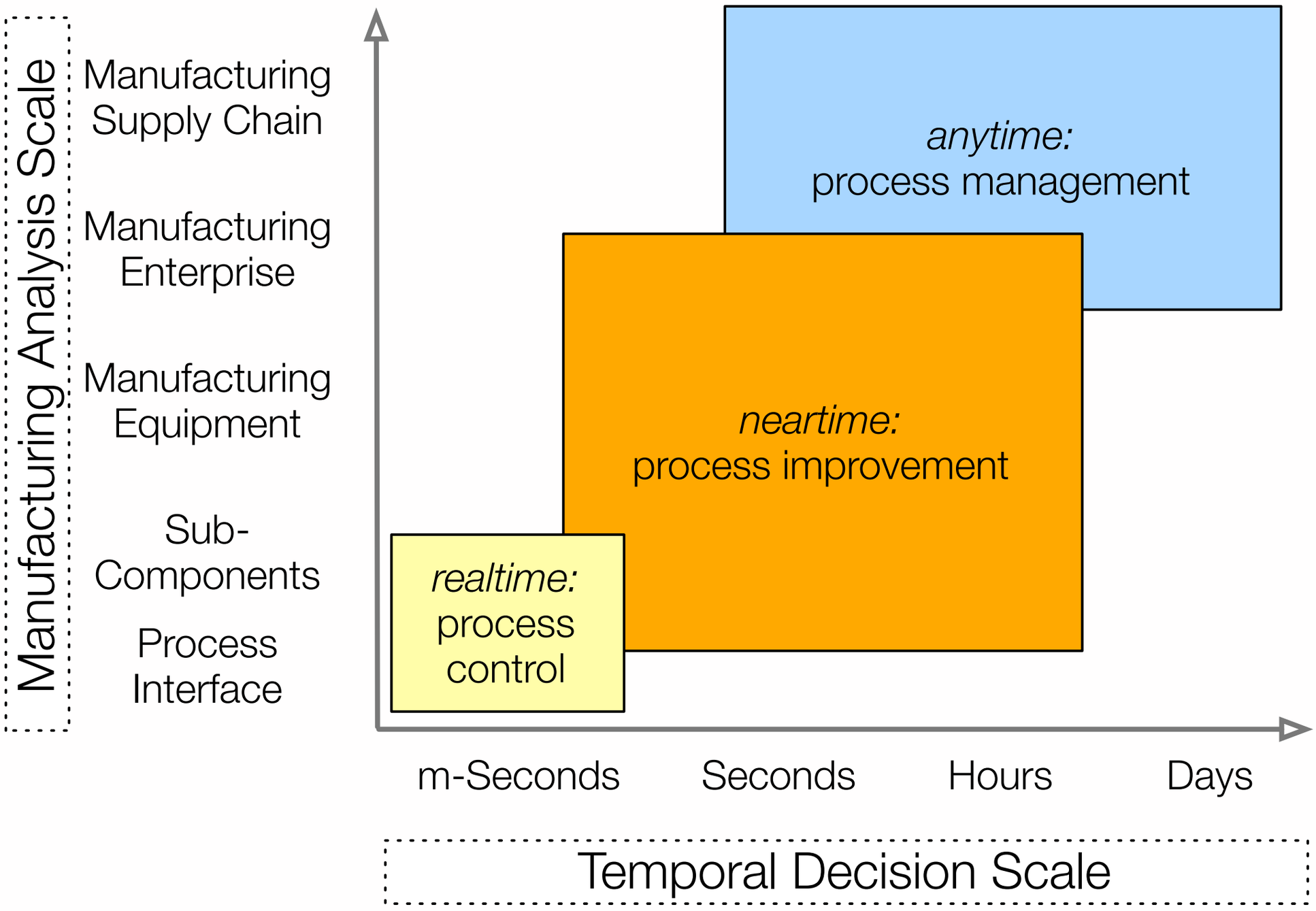
Temporal Decision Scales

Temporal scales can vary from μ-seconds to days



The Internet of Manufacturing Things

Enabling technology for:

High speed data from heterogeneous sources

Integration across software and hardware platforms

Decision-making across spatial and temporal resolutions

IoMT vs. IoT

- Enterprise focused
- Islands of excellence – integration missing
- Mature markets

Closing Thoughts

- Terrific potential
- Being domain specific helps – a lot
- Don’t reinvent the wheel
- Everything is connected