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The Intel Factory – Internet Of Things (IoT) and Large Scale Data Analysis in the Manufacturing Environment
英特尔工厂——在生产环境下的物联网和大数据分析

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IT@Intel

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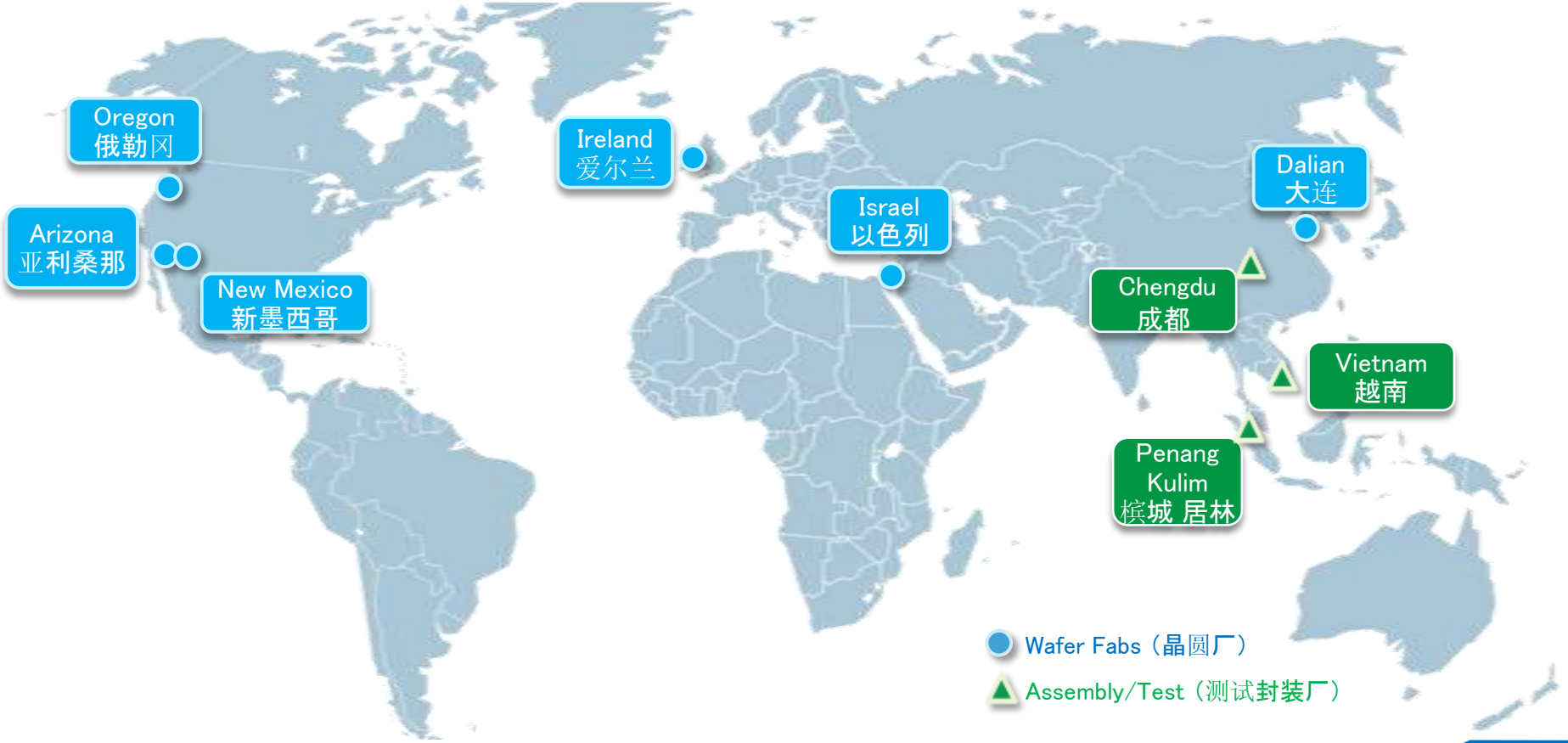
Fab and Assembly / Test Sites 晶圆和测试封装厂



Overview 综述

Topic: The Intel Factory – Internet of Things (IoT) and Large Scale Data Analysis in the Manufacturing Environment

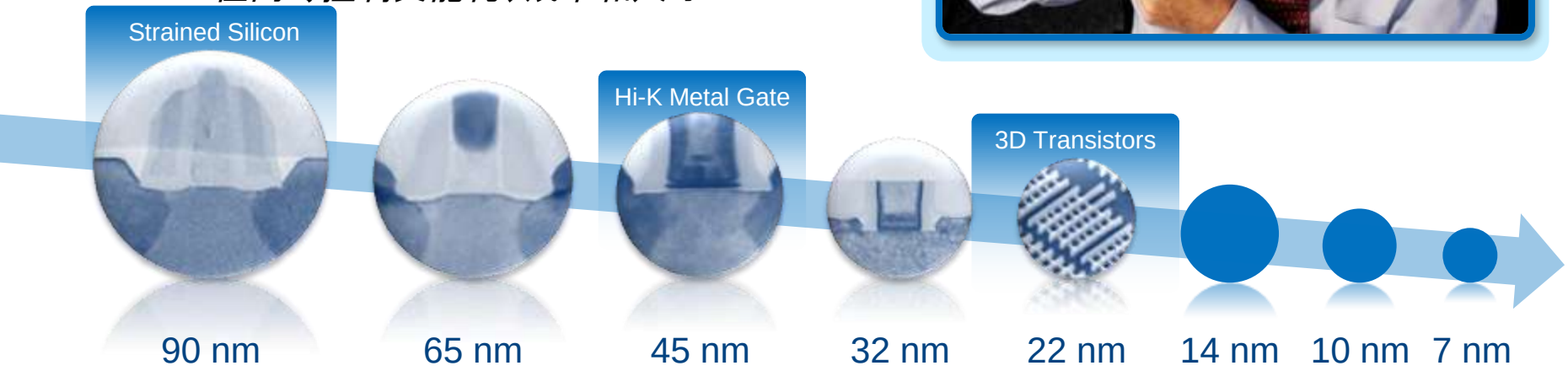
主题:英特尔工厂——在生产环境下的物联网和大数据分析

- IoT and Sensors in the manufacturing environment 生产环境中的物联网和感应器
- Data size is exploding 数据量呈现爆炸式的增长
- Benefits of consuming all that data 使用这些数据的好处
- Examples of how we are leveraging sensor data 我们如何利用感应器数据的实例
- Vision of the future 展望未来

Predictable Silicon Track Record
Executing to Moore's Law
按照摩尔定律中
硅的可预测发展历程

Enabling new devices with higher functionality and complexity while controlling power, cost, and size

让新的设备有更良好的性能，技术更为复杂但同时控制其能耗、成本和尺寸



Why Internet of Things (IoT)? 为什么要利用物联网

$B's in semiconductor process equipment, IoT is leveraged to
半导体生产设备动辄几十亿美金，物联网被用来帮助

- Reduce capital cost 降低资产成本
- Increase quality 提高质量
- Improve time to market 缩短产品的上市时间

"Intel's strength has traditionally come from its manufacturing prowess."

——Andy Bryant

"英特尔的优势在于其超凡的制造能力"

——安迪·布莱恩特

Intel, AZ
美国亚利桑那州

IT in the Intel Factory 英特尔工厂中的 IT 环境

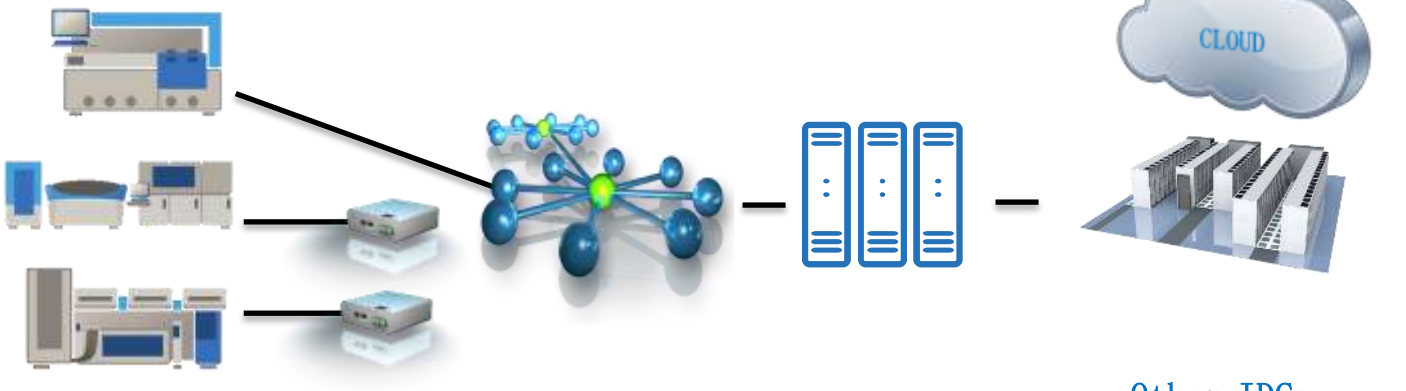
Data Center: 数据中心

- Intel x86 64 bit servers 英特尔x86 64位服务器
- Multiple Operating systems 多操作系统
- Routers, switches, firewalls 路由器、交换机、防火墙
- Fiber optic cabling 光缆
- Greater than 1PB of centralized storage 超过 1 PB的中央存储

Factory Floor: 工厂

- Thick Clients (all Intel x86 64 bit desktop platforms) 功能强大的客户端电脑 (英特尔x86 64位台式机)
- Production Semiconductor Tools 半导体制造机器
- Access switches and Wireless Application Protocol (WAP)接入交换机和无线应用协议
- Vast array of Ethernet cable 广泛部署的以太网线缆

Intel IOT Smart Manufacturing (Penang)



Equipment

Gateways

Manufacturing Network Infrastructure

Localized Industrial Data Center

Other IDCs
Enterprise DATA CENTER
B2B Cloud

Intel's Assembly / Test – sensors and analytics help maintain productivity*.

Predictive **Maintenance**

Sensors as Part of the IoT Network 物联网中之感应器

Leveraging sensors in process equipment
利用生产设备中的感应器

- A tool often has many sensors
  一台机器有很多感应器
- Sensors actively monitor temperature, pressure, and chemical balance within the tool 感应器主动监控机器的温度、压力、化学品平衡
- For example, a tool used to deposit metal (sputtering) often has sensors that monitor pressure, temperature, gas composition, etc.
  例如，金属涂膜的机器常常有感应器监控压力、温度、气体成分
  - For gas composition, monitoring is often measured through residue gas analyzers (RGA's) 气体成分的监控常常通过残余气体分析器

So What's New? 什么是新的

- Shifting to real-time decision making 转向实时决策
- All data instantly available (Wi-Fi, 3G, etc.) 所有的数据即刻可用
- Large data oceans for later mining 大数据海洋为以后数据挖掘所用
- Advanced Analytics 高级分析法
  - Integrated dashboards 整合的仪表板
  - Analytics at the Edge 边缘分析
  - Streaming data analysis 流数据分析

Data Size is Exploding 数据量激增

- In each major processor release, the amount of data required to build the wafer doubles in size. 每一个主要处理器的发布，晶圆产生的数据都成倍增加
- Other companies data size 其他公司的数据量
  - Facebook ‘status’ updates made per day are 55 million [reference] 脸书每天“状态”更新是 5 千 5 百万
  - Twitter has roughly 500 million tweets per day [reference] 推特大概每天有5亿条推文
  - Google has roughly 3.5 billion searches per day [reference] 谷歌每天大概有35 亿次搜索
- Intel collects over 5B sensor data-points per day per factory and it’s growing. 英特尔每天每个工厂采集50多亿个数据点，而且它还在增加

A Single Wafer 单片晶圆

Fast analytics against large and changing datasets is challenging. However, our focused approach results in increased yield and faster through-put-time.
对不断变化的大数据集进行快速分析充满挑战。然而我们专攻的方法令产品质量良率更高，产出的时间更短

Intel sorts 1000's of wafers per day 英特尔每天处理 1000 片晶圆

- Each wafer has roughly 1 GB of data 每片晶圆大概产生 1 GB 的数据
- Each wafer must be analyzed as well as incorporated into the baseline 每片晶圆都必须被分析和并入基线

A single wafer ~1 GB of data with 1,000's of wafers/day analyzed against a historical baseline demands a robust computing infrastructure!
每天的分析将~1GB数据/1片晶圆 × 1000片和历史数据对比
需要非常稳健的计算环境

Sensors Benefits and Challenges 感应器的优势和挑战

Sensor Technology brings great benefits 感应器技术带来了极大的好处

- Monitor product quality with immediate feedback 监控产品质量并及时反馈
- Minimize loss by stopping a tool when it has a problem 当机器出现问题时将其停止以尽量减少损失
- Real-time feedback 实时反馈

Challenges 挑战

- Data volume is large (100's of points per second per sensor collected) with 1000's of sensors throughout a factory 数据量很大(每秒每个感应器收集100个数据点), 每个工厂有 1000 个感应器
- Time Series analysis is complex 时序分析很复杂
- Processing real-time feedback is not trivial 处理实时的反馈非常重要

Data Consumption Life Cycle 数据消耗的生命周期

Key Traits 主要特点

- Data Integration 数据整合
- Data Traversal (drill-down) 数据遍历(向下挖掘)

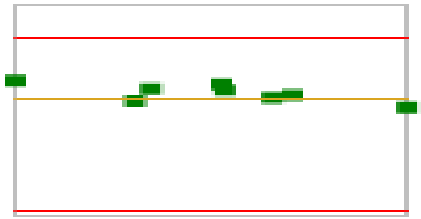
Storage 存储
- 100's of points/second每秒100个数据点
- Terabytes of summary data; Fast read/write 兆兆字节的总计数据，快速读写
- Archiving归档

Mining 挖掘
- Correlation关联
- CPU, IO and network Intensive

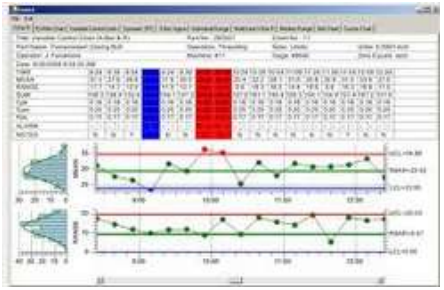
Integration 整合
- Combining data 整合数据
- Facilitating drill-down 便于向下挖掘

Notification 通知
- Millions of charts; prioritize and notify 百万张图片，按重点排序并发出通知

Reporting 报告
- Web; mobile; desktop 网站、手机、台式机
- Actionable Information 可采取行动的消息



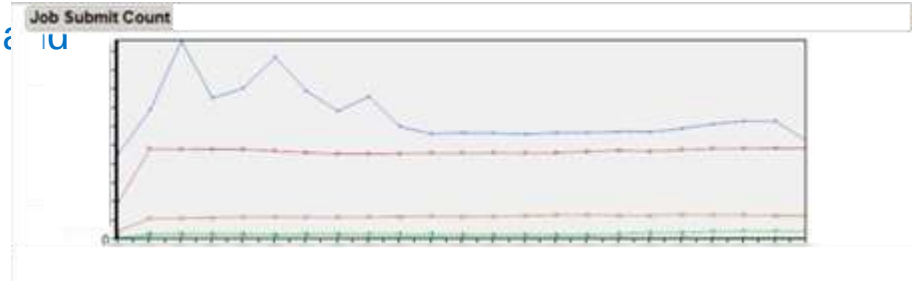
Control Chart Example



Example from Quinn-Curtis Inc. Not Intel data.

Distributed Data Analysis (Ad-hoc & Continuous)
分布式的数据分析(按需和持续)

- Intel manufacturing has unmatched innovation a[illegible]d execution
  英特尔工厂有无与伦比的创新和执行力
- Powerful server farms are available for ad-hoc/real-time analysis as well as continuous analysis
  强大的服务器集群可用于按需/实时分析，以及持续的分析
- Engineers create analysis/reports leveraging the farms for this data analysis
  工程师利用这些集群做数据分析的各种报表
- Jobs are distributed across the world as required
  计算工作按需分布在全球各处



Process over ~500K ad-hoc jobs/week
处理超过 50 万次按需的分析工作

Content Delivery 内容发布

- Shifting to HTML5 转移到 HTML5
- HTML5 provides content to any platform any where HTML5 随时随地提供内容
  - Phone, tablet, laptop, desktop
    手机、平板、笔记本电脑、台式机
  - Point and click is popular 点击式相当受欢迎
- Any new platform brings new challenges 任何新的平台都会带来新的挑战
  - JavaScript, jQuery, Angular, etc.
  - CSS
  - Graphing
  - New infrastructure challenges

- Think of your favorite free phone app 想象一下你最喜欢的免费手机应用
- This level of performance is the new baseline expectation of your user community! 这种性能水准是你的用户群体的基本期望！

HTML5 – a truly rich user experience!
HTML5——真正丰富的用户体验

Examples 案例

A Key Shift in Data Analysis 数据分析的关键变化

Mining large data-sets is important; but just as important is the ability to traverse the hierarchy of the data. 大数据集的挖掘很重要，但是对层级数据的遍历同样重要

For example, if the police was looking for a car owner in the United States 比如要寻找一位美国车主

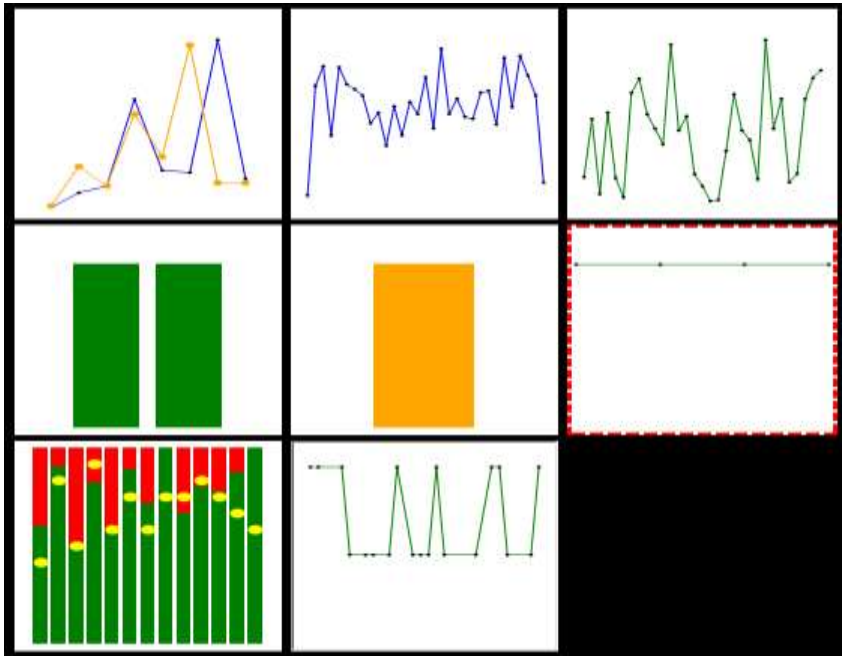
- First search all 50 States DMV records for the license plate; find a plate match for the car; find an address for the owner; get a map to that address; then find the car owner首先搜索 50 个州的车辆管理局的牌照；匹配牌照和车辆；找到车主的地址；找到相应地址的地图；然后找到车主
- This example illustrates how data needs to be combined and traversed to solve problems 这个例子表述了数据怎样合并和来回移动以解决问题

Semiconductor data is very similar 半导体的数据非常类似

Traversing the data hierarchy is critical
来回遍历层级数据非常重要

Advanced Analytics & Manufacturing Tool Sustaining
高级数据分析和工厂生产设备的持续运作

- The process engineer's job requires monitoring yield, cycle-time, up time, process health, maintenance, etc. 制程工程师的工作需要监控良率、运转率、可用时间、生产过程的稳健和维护等
- Adv. Analytics is used to pull all the data together into actionable information on any platform with visual indicators and drill-down capability 高级分析用来将所有的数据整合处理，并将处理结果用显示工具显示在任何平台上，并且可以进一步分析
- Investigatory interaction available 交互式的调查
- Savings measured in quality, labor, improved yield, Through-Put-time (TPT), etc. 可以用质量、人力、提高的良率、产出时间来衡量节约



Analysis that used to take 4 hours done in under 30 seconds
从 4 个小时的分析缩短到 30 秒

Accelerating Factory Output 加速工厂产出

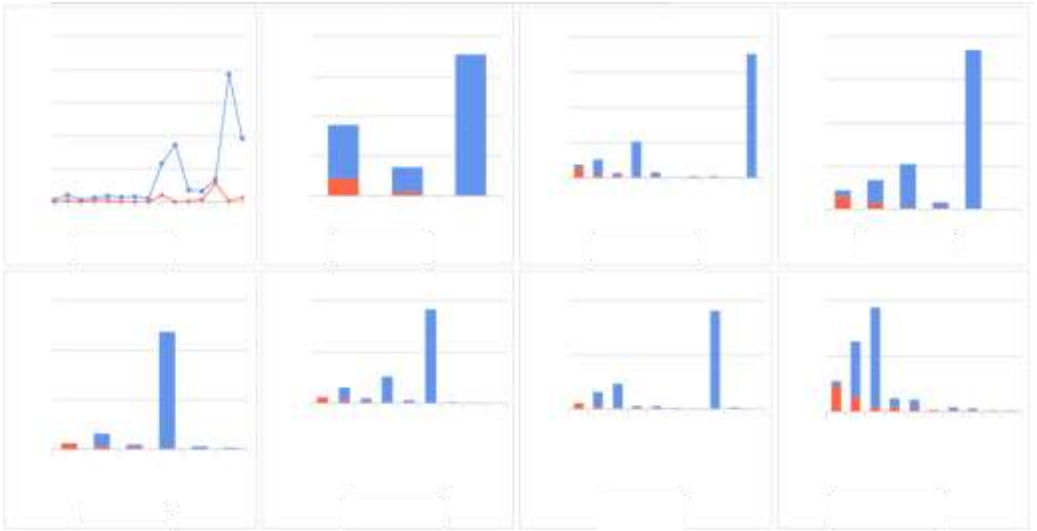
- A new Advanced Analytics methodology was created to look at the hundreds of operations in the line to identify issues real-time. 新的高级分析方法用来实时寻找有上百个工序的产线的问题
  - Finds issues in seconds; drill-down, etc. 在几秒钟内找到问题，深入分析
- The analytics provided insight otherwise not possible at the time. 这种分析提供以前不能做到的洞察
  - Daily action against issues identified. Analytics helped focus the team. The results were significant. 制定针对问题的每日行动。分析帮助团队关注问题。益好不容忽视。

This summarized portion of a manufacturing line puts hundreds of steps into a single visual, a Pareto chart, with interactive bars to reveal additional details. FOR ILLUSTRATIONS PURPOSES ONLY.

Significant improvement in TPT;
millions saved through the use of Advanced Analytics
极大的缩短了产出时间。使用高级分析方法节约了数百万美金

Tool Sensor Data (Fault Detection Control)
机器感应器的数据(故障监控控制)

- Real time sensor data from equipment collected (huge volumes of data – 100's of points/second/sensor) 机器采集的实时感应器数据(大数据量, 100个点/秒/感应器)
- Data extracted; analyzed for both real-time detection as well as end of line correlation 数据提取;实时和全线的相关分析
- Meaningful reporting created for engineers and manufacturing technicians 为工程师和高级技术工人提供有意义的报告



Processing over 5 billion points per day results in measurable improvement in equipment availability and yield improvement.
每天分析超过 50 亿数据点, 使设备更为稳定, 良率获得实际的提升

Tool Maintenance 设备维护动态调整

- Preventative maintenance ensures tools behave in a predictable manner 预防方式的维护保障设备在可预计的状态下生产
- Advanced analytics allows the part replacement frequency during maintenance to be correlated to end-of-line yield 高级分析允许备件的更换频率和最终的良率相关
- Parts that do not impact yield are adjusted in their replacement schedule 对不会影响到良率的备件，其更换安排会有一定调整
- Reduced part replacement leads to less downtime (increased equipment availability) and reduced maintenance costs without impact to quality 减少备件更换，便能减少停机时间和成本，而对产品质量没有影响

$M's saved in parts replacement without compromising quality with additional benefit to increased equipment availability
备件更换上节约了数百万美元，质量没有降低，而设备更为稳定可靠

Adaptive Metrology at the Station 调整式的测量

- When the tool is running production material we do regular quality checks to ensure the tool is healthy 当机器在生产时，定期检查产品质量以确保机器正常运行
- We leverage advanced analytics and modeling to improve quality across manufacturing by dynamically adjusting the monitor frequency 利用高级分析方法和建模，动态调整监控的频率来提高质量
- Dynamic tool monitoring supports our manufacturing excellence. Benefits include savings through increased yield while reducing scrap, improved cycle-time, tool availability and labor efficiencies. 动态设备监控支持卓越的制造流程。其优势包括通过提高良率来减低报废、提高流转率，机器更为稳定可靠和人力效率更高

Significant gains measured on constraint tools through adaptive monitoring!
通过调整式的监控生产设备，获得巨大的收益！

A Vision of the Future 对未来的展望

One Vision of the Future 展望未来

Where we could go… 我们应该

- Every sensor is wirelessly connected to the network 每一个感应器都无线连网
- Edge analytics pro-actively finds impending equipment failures 边际分析用来提前发现即将发生的设备故障
- Sensor system checks equipment inventory, if replacement parts not available, order automatically placed to the vendor 感应器系统检查设备库存，如果待更换的备件没有存货，就自动向供应商提交订单
- Equipment parts delivered; system looks for next maintenance cycle to replace parts; system validates that properly trained people are available to do work and are on-shift (vacation system checked). All clear then… 备件运到以后，系统检查下一个设备维修周期以替换备件。系统查找合适的有能力的人来替换备件(查询休假系统)。当所有情况和系统都清楚以后
- Work done on schedule; no unscheduled downtime occurred 替换工作按时完成。没有在计划外的停工事件

Data Integration leads to higher equipment availability and utilization.
Potential to lower capital costs and improve cycle time
数据整合导致设备更稳定和使用率更高。可能帮助降低资产成本，提高生产效率

How Does Intel Fit into this Picture
英特尔在这方面是怎么做的

Two new vectors are pushing on the data center 两个新的方向推动数据中心的发展

- Big data requires powerful Intel servers to analyze the ocean of data 大数据需要强大的英特尔服务器来分析海量数据
  - Memory, CPU, disk space, network interconnectivity all matter 内存,CPU, 硬盘空间, 网络互联都很重要
- Shifting to support HTML5/mobile results in the processing moving from the client (phone/tablet) to the servers 转移到 HTML5 和移动设备的话, 需要将计算处理的工作从客户端(手机/平板)转移到服务器中

Intel Internet of Things (IoT) sensors provide a data connection from end device to the cloud 英特尔物联网感应器提供了从终端设备到云端的数据联系

- Moon Island™ , Quark™, Galileo™ are enabling new data streams

Data demand is requiring more from our data centers
由于对数据的需求, 导致对数据中心必须提供更高的计算容量和功能

White Paper
October 2015

IT@Intel

Joining IoT with Advanced Data Analytics to Improve Manufacturing Results

With tools based on this approach, factory engineers and managers can perform analyses that used to take 4 hours in just 30 seconds.

Executive Overview

Intel's factory system has delivered more and more computing functionality at ever-lower cost for decades. Intel's Manufacturing IT engineers are using a combination of the Internet of Things (IoT) and large-scale data analysis to lower costs, increase product quality, and continue Intel's predictable silicon track record. They coordinate manufacturing operations in multiple factories worldwide, collecting and integrating data from various sources, adapting analytic methods to cope with exploding data volumes, and achieving world-class results.

The factories' IT engineers realize the potential value of IoT and large-scale data analytics in three ways: analyzing large volumes of data, identifying the most useful data, and reporting that data in a way that meets the needs and expectations of process engineers, yield engineers, and factory managers.

They have found several use cases for advanced analytics in their manufacturing environment:

- Increasing uptime for manufacturing tools with advanced analytics
- Accelerating factory output
- Detecting and controlling faults with tool sensor data

With tools based on this approach, factory engineers and managers can perform analyses that used to take 4 hours in just 30 seconds.

Steve Chadwick
Manufacturing IT Principal Engineer, Intel IT

IT@Intel

基于高级数据分析技术的物联网解决方案助力提高制造水平

要点概述

Steve Chadwick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