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Pharmaceuticals Industrial Automation
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The Nature of the Beast

How the Industrial Environment Shapes Computer Systems

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Product and Technology Architecture
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In a Nutshell

The nature of an industrial plant, its business context, and organizational structures, drive customer needs that ultimately determine the architecture of industrial computer systems

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The Industrial Environment

- The Physical Environment
 - An assault on the senses
 - Often very dangerous
 - Large and complex arrangements of equipment
 - Geographically large sites
 - Very large quantities of raw materials and product
- The Business Environment
 - Rapidly changing markets for products
 - Variation in cost and quality of raw materials
 - Increasingly stringent regulatory environment
 - Capital intensive plants
 - Valuable products and expensive raw materials

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The Physical Environment in the Alumina Industry



Bauxite → Alumina (Al_2O_3)


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The Physical Environment in the Alumina Industry

- The process is large scale and dangerous
 - 100,000 tonnes of 150°C caustic soda circulating continuously
- The plant is geographically very large
 - approx 4 square kilometers in size
 - 4 main process areas + 60 megawatt power station
- The plant is very complex
 - 1,000 valves, 500 pumps, 100 large vessels, 500 - 1,000 people
- The plant consumes and produces large quantities of material
 - 2 - 3 million tonnes of Alumina produced annually

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The Business Environment in the Oil Industry



Crude oil → gasoline, diesel, jet fuel, kerosene, LPG, bitumen etc

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Operator - Needs and Responses

"Vigilance and response"

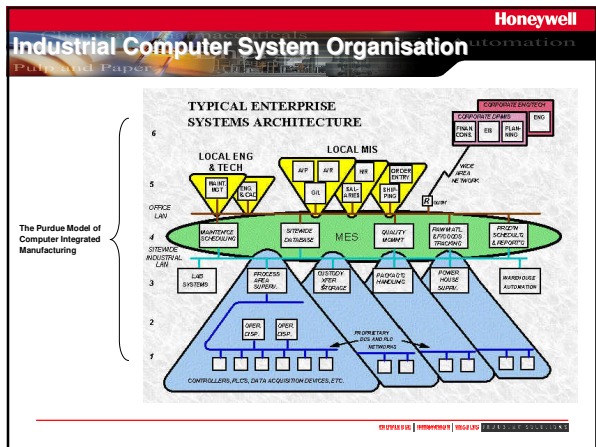
Customer Needs	Architectural Response
Guaranteed access to the process ("continuity of view")	Component redundancy Redundant communication paths
Rapid identification of abnormal situations	Rich, real-time user interfaces Real-time databases Reliable, distributed notifications Short term historical data
Support for very large numbers of controllers	Distributed databases Publish-subscribe distribution of data
Low impact maintenance and upgrade	"On process" software migration
Clear definition and enforcement of operator roles and responsibilities	Information segregation and scope of responsibility models
Auditability and admissibility	Electronic signatures, digitally signed journals
Usability	Standardised user experience Highly specialized computing environment Simplicity, consistency, redundancy

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Production Planner - Needs and Responses

"Delivering on customer commitments"

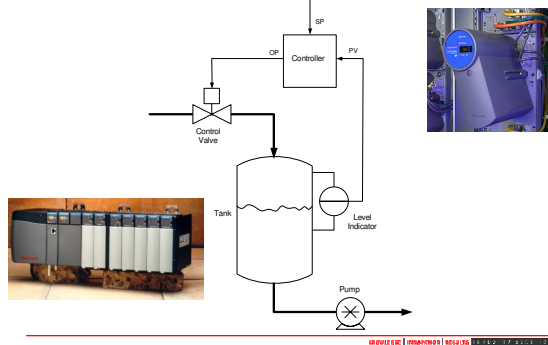
Customer Needs	Architectural Response
"Consequence-free" access to the process	Process data replication Firewalls between users and the real time control system
Long term reporting and analysis	Centralized databases Long term compressed historical data Data marts and data warehouses
"What-if" production scenario building	Offline rather than online models
Access to commercial data	Generic system interfaces -XML, Web services etc
Support for large numbers of users	Less rich, less real-time UIs, web UIs
Clear definition and enforcement of user roles and responsibilities	Information segregation and scope of responsibility models
Auditability and admissibility	Electronic signatures, digitally signed journals
Usability	Personalized user experience Regular office computing environment



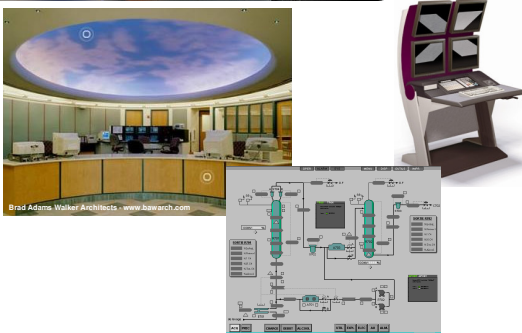
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Architectural Patterns
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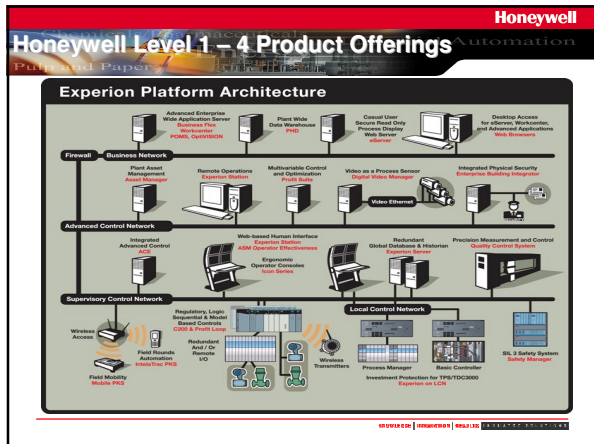
- Real time, high availability components are concentrated in the lower levels
- Publish-subscribe mechanisms at lower levels
- Query-response mechanisms at upper levels
- Data is aggregated up through the levels becoming broader in scope
- Scalable UIs are concentrated in the upper levels
- Relational databases at upper levels
- Real time/object databases at lower levels
- Activity at one level is isolated from other levels
- Interfaces to external systems at all levels
- Security is important at all levels although the nature of the threat varies
- At this level of detail the "components" are often systems in their own right with their own architecture

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Level 2 Control Room Environment
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- ## Future Challenges
- Automation
- Security
 - Post 9/11 recommendations and regulations focus specifically on industrial process control systems
 - Technology
 - Wireless technology will push the capacity of control systems
 - Changing Demographics
 - The current population of operators is going to retire and there is no one to replace them
 - Many others...

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- ## The Role of Software Architecture
- Automation
- The practice of software architecture provides the link between customer needs and architectural responses
 - The software architect needs to:
 - Hear and understand the needs of the customer
 - Systematically express the needs of the customer in terms of specific quality and functional requirements
 - Analyze the requirements in order to formulate a system architecture that meets the requirements

Summary

- The nature of an industrial enterprise leads to a layered organization of personnel and supporting computer systems
- The various levels of an enterprise have different concerns that produce different architectural responses at each level
- The role of the software architect is to systematically respond to customer needs with suitable software architectures
- The nature of other domains (e.g. banking, insurance, commerce etc) similarly determine the structure of computer systems in those domains
