This course presents the methodological and technological innovations of IMAGINE. Emphasis is put on the architecture and core components of a service-oriented software platform. This platform acts as a single point of integration for all enterprise information systems involved in a manufacturing network and it allows the inclusion of manufacturing events that have an impact on management decisions. In two different application scenarios from the aerospace and automotive sectors, respectively, we show how this integration platform is embedded in the context of two different tool environments.

Contributors

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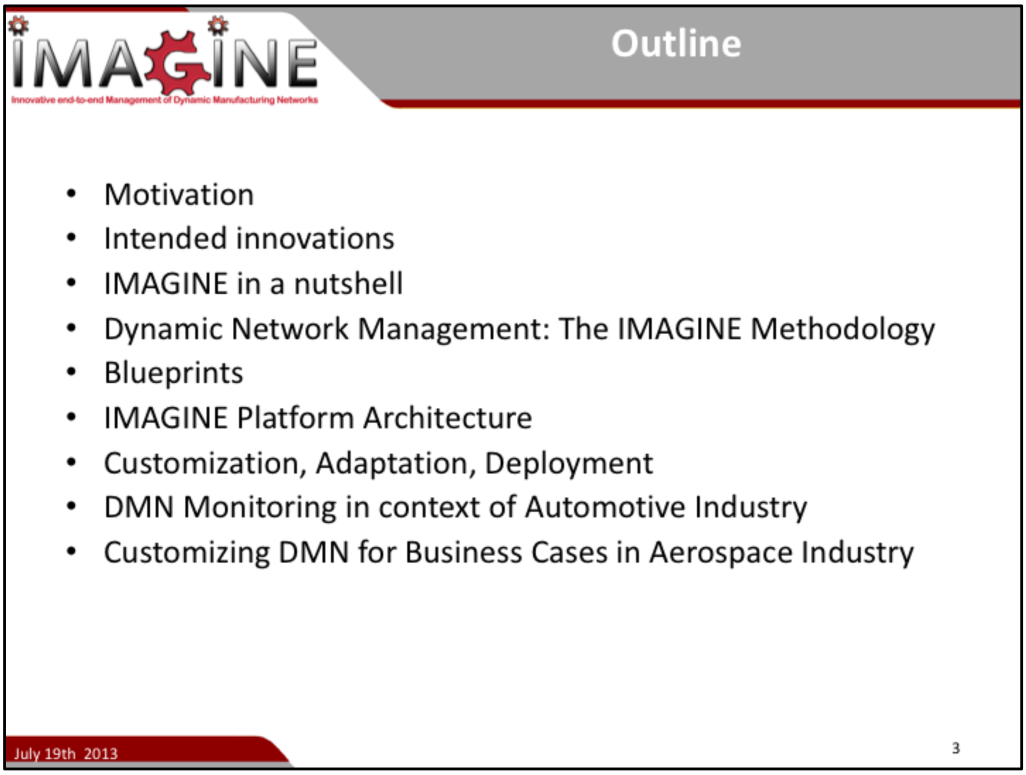


In this course we'll first introduce our concept of Dynamic Manufacturing Networks (DMNs) that motivated the project's conceptual and technological innovations in the management of DMNs. We'll then focus on the core contributions of the IMAGINE project:

- our methodology to configure, design and monitor the operation of specific manufacturing networks,
- the blueprint approach aiming at standardized information pool about all aspects relevant to the formation and re-configuration of a network and, finally,
- the architecture of a generic information platform that will be interfaced to specific supplier systems through application specific adapters.

These three main project contributions will be discussed in further detail before we conclude with the application of these findings to two different business domains: automotive and aeronautic industry. In the automotive domain, the focus is on monitoring Dynamic Manufacturing Networks, while the focus in the aeronautics business cases is on customizing the methodology and the blueprint modle and embedding the generic architecture into domain-specific system components. Both vertical business domains represent two out of five domains the project is exploiting in the form of so-called Living Labs.

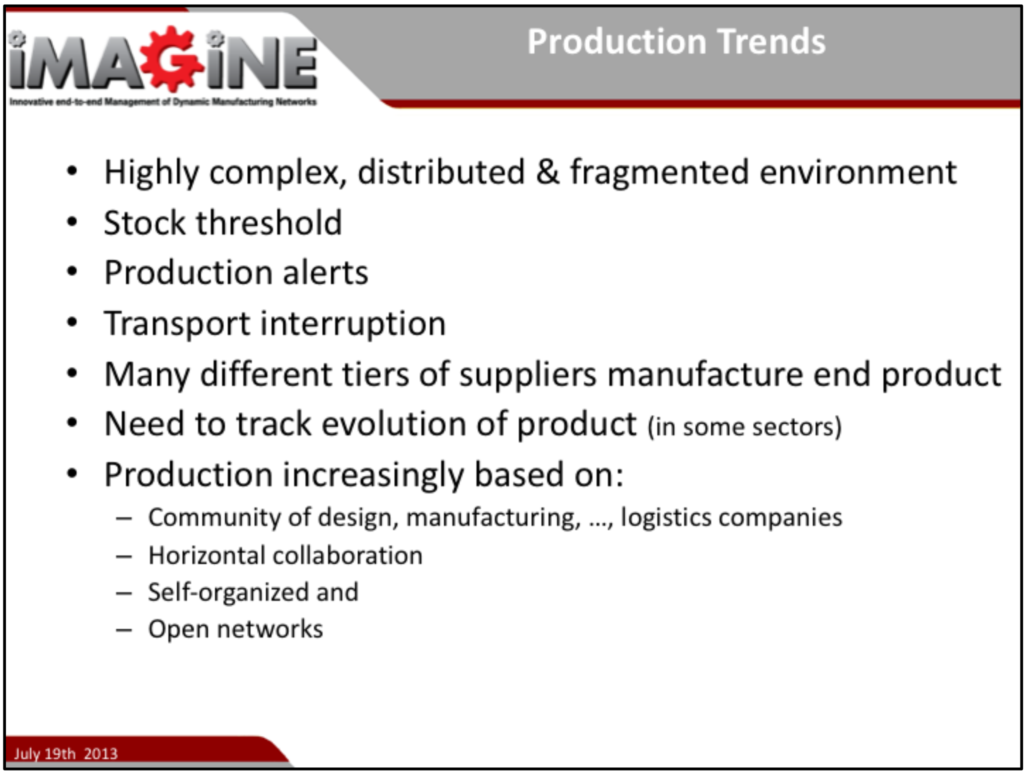
In this course our focus will be on the role of blueprints and on the platform architecture, its components and features and the principles underlying its design.

The IMAGINE methodology, which we will briefly sketch here, has been explained in more detail in Course **BMT1.**

Our notion of Dynamic Manufacturing Networks aims to:

- Address current trends in the way products are conceived and manufactured,
- Overcome the deficits of current manufacturing practices and
- Understand and meet the requirements of dynamic manufacturing networks

After discussing these challenges in more detail, we'll sketch the project's approach towards an end-to-end Dynamic Manufacturing Network Management methodology and supportive technology.



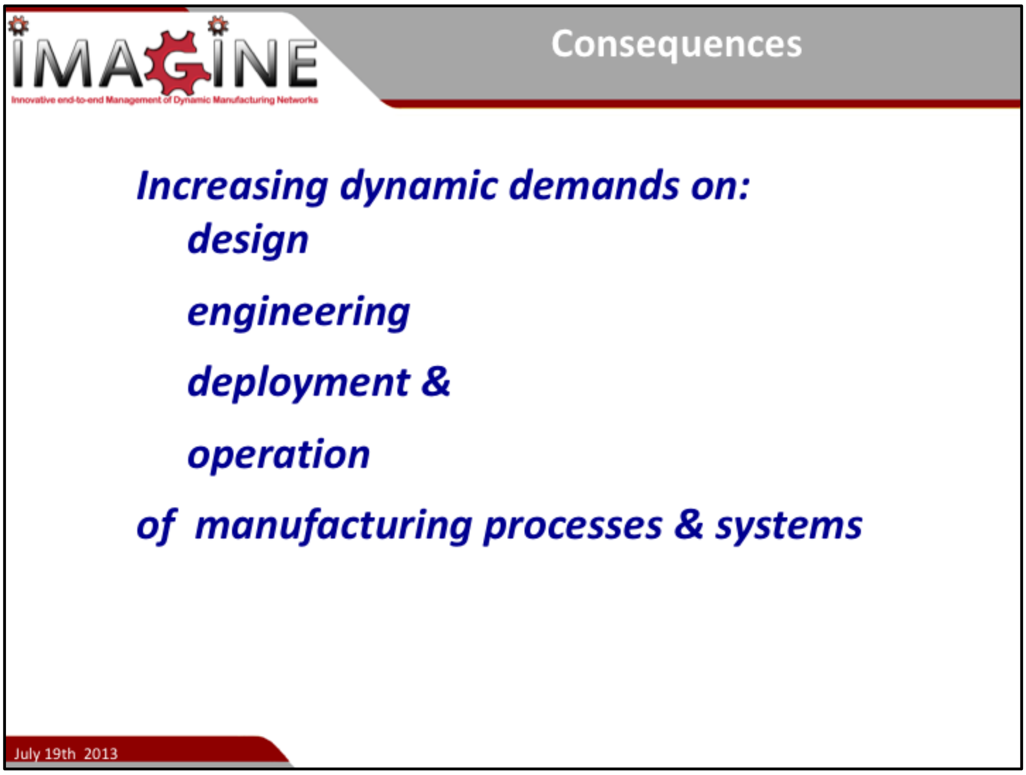
Manufacturing companies are facing many new challenges today. The German association of car industry, for instance, lists more than 700 suppliers of automobile parts in Germany alone. This gives you a feeling how fragmented the automotive and many other manufacturing domains are these days. But Volkswagen, Mercedes, BMW and others also have suppliers in Austria, China, Spain, Czech Republic in many other countries. This means that products are increasingly built in networks of part suppliers, manufacturing facilities, logistics specialists, and transport service providersand often, such networks are geographically dispersed world-wide.

Parts and products are often produced when they are needed, thus reducing the need for warehousing, while increasing the risk of distribution interruption, which may even stop production because in times of lean production, stock is just kept on rail or on freeways. Remember the eruption of the Island volcano Eyjafjallajokull in March 2010, which caused the interruption of air traffic to and from Europe for about a week, or the tsunami in Fukushima, which made industry production rates fall by more that 10% in Japan and also affected economy globally because important electronics manufacturers had to evacuate certain production sites.

Often they use many different tiers of suppliers to manufacture the end product. Increasingly, OEMs are using more pre-assembled parts from a globally distributed network of suppliers who come and go rather quickly

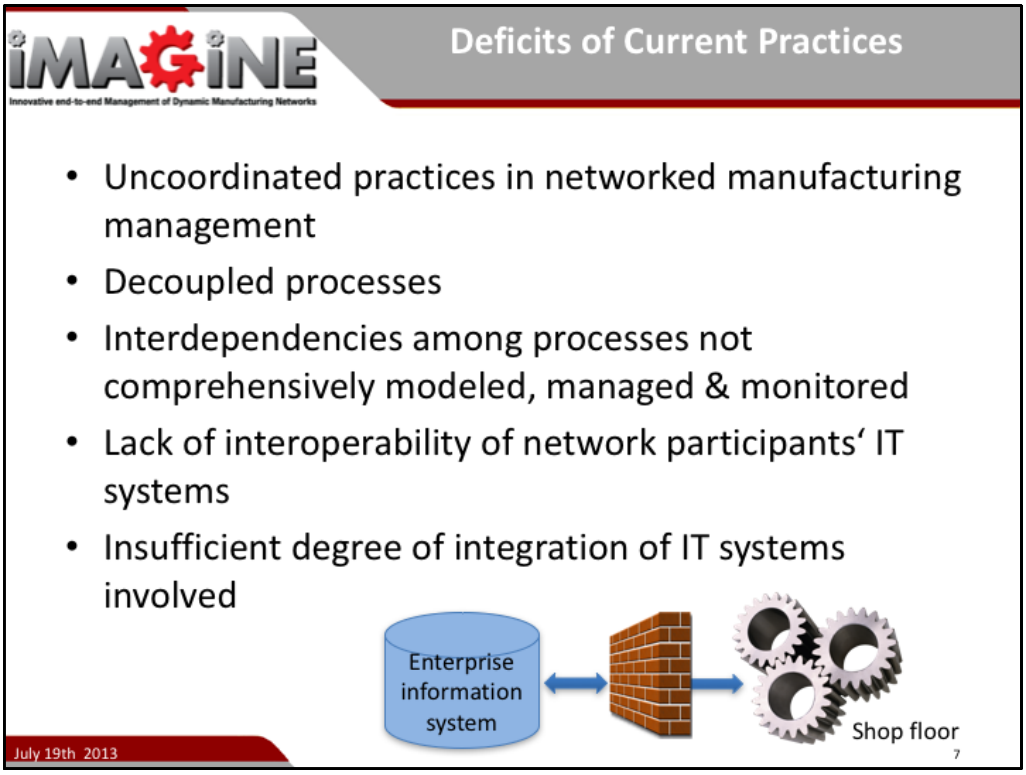
In some sectors incl. aerospace, defense, or automotive industries manufacturers need to track design and production processes and create a genealogy of their products ranging from the raw materials used to finished products. In many cases they must trace not only their main product produced through its entire life cycle with end customers but also their secondary or incidental products deriving from the core manufacturing process.

Further trends we observe include
- Crowd-sourced product design, which is enabled by standardized software tools,
- Horizontal collaboration, which occurs between partners at the same level of the production process to benefit, e.g., from shared supply risk, reduced administration cost, aggregated purchasing quantities.
- Open and self-organized manufacturing networks, open in the sense of open to collaboration, open to fair participation, and open to share manufacturing information.



These new trends impose high demands on all phases of manufacturing processes and systems to react in time and adequately on dynamic changes affected by weak elements in the actual production network.

But several deficits in current practices hamper appropriate measures.

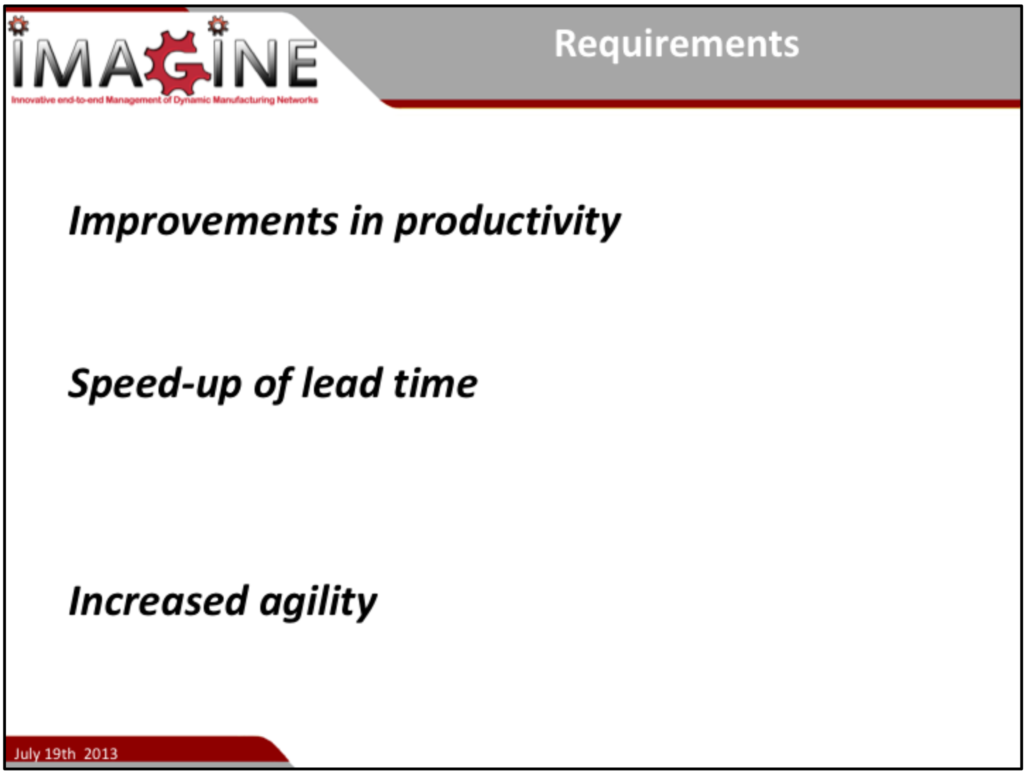


Currently, processes and activities in networked manufacturing management are not satisfactorily coordinated because the information needs of these processes and activities and interdependencies between processes are often not fully understood, let alone explicitly modeled and specified.

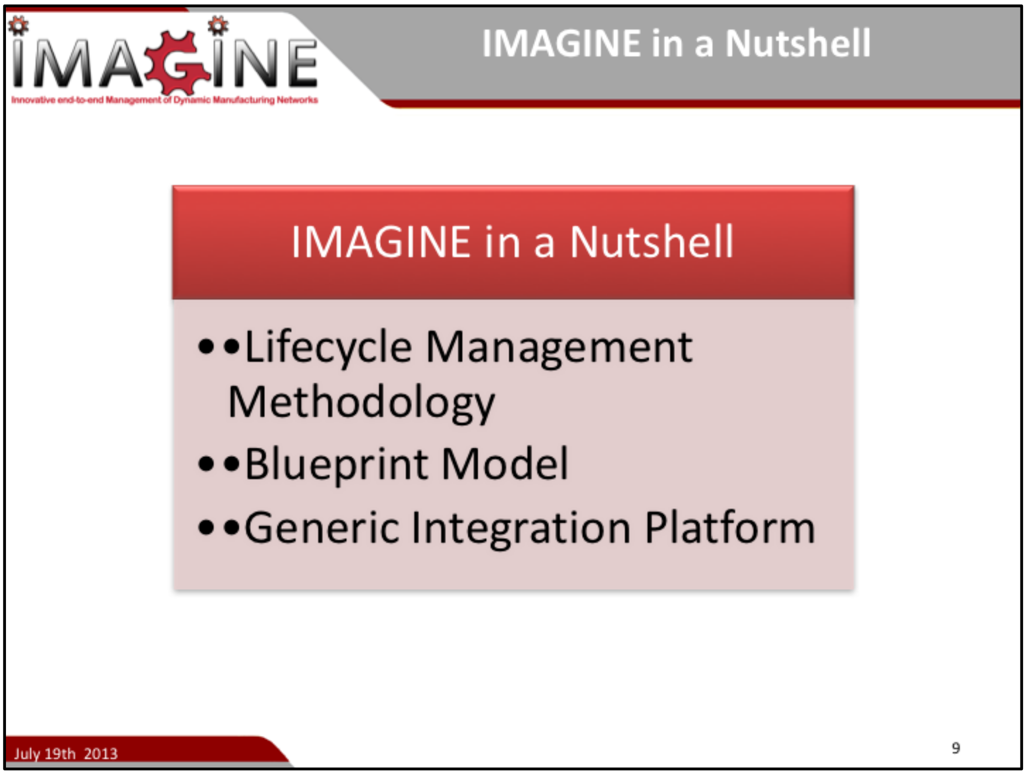
Increasingly, OEMs are using pre-assembled parts from a globally distributed network of suppliers who come and go rather quickly. In order to maintain profitability, companies need to seamlessly and securely integrate their IT systems to suppliers' in order to track product, supplies, schedules, and respect product deadlines.

Manufacturing network management, product lifecycle management (PLM), production and IT systems typically come with their own terminology and practices, which makes it difficult to establish a holistic management and monitoring approach. Although plant operations may have an impact on the results inventory, on resources, products and more, there often exists an impermeable wall between the plant floor and the enterprise's information system.

Without an automated manufacturing workflow, it is easy to forget a step in the workflow, refer to the wrong document, or forget to communicate important data resulting from the production step. Consequences can be progress slow-down or even a complete halt.



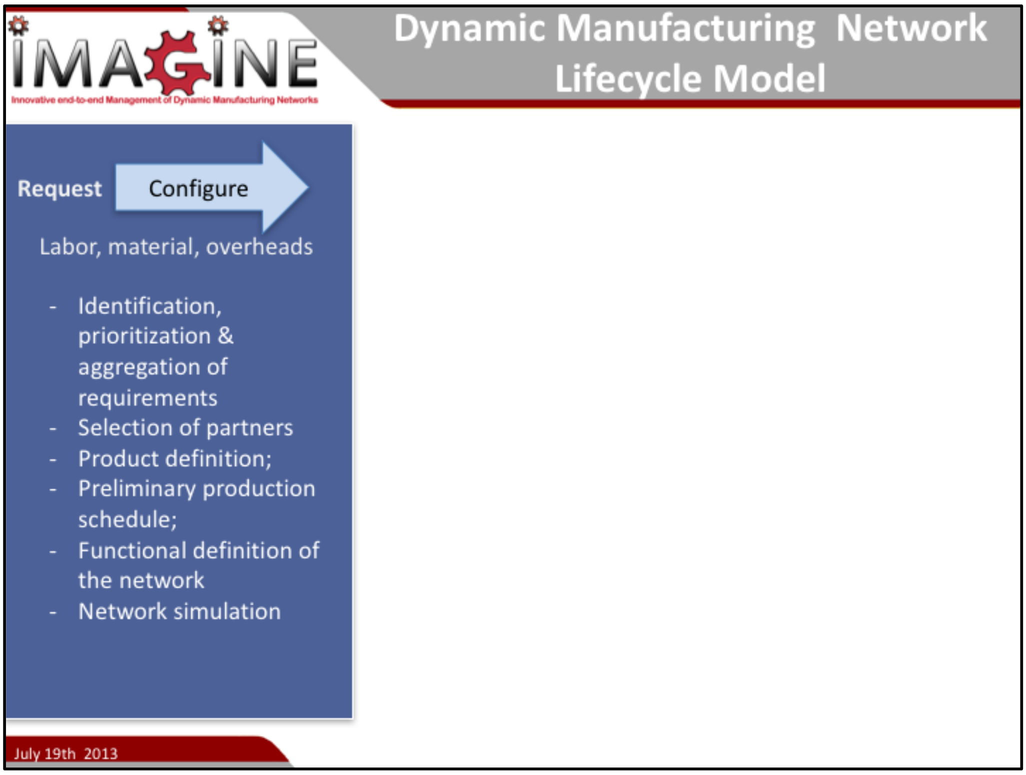
To achieve improvements in productivity, a speed-up of lead time and and increased agility in the design, engineering, deployment, & operation of manufacturing processes & systems, the project provides several answers that will be presented in the next section.



In this section we'll briefly

- present the IMAGINE end-to-end lifecycle management methodology,
- Explain the blueprint approach and the role of blueprints in the design and performance of manufacturing network, and, finally,
- Dissect the generic integration, or i-platform, that is shared by all living labs representing a range of vertical manufacturing domains.

In the sequel, we use the term dynamic manufacturing network, or short, DMN, to denote a permanent or temporal coalition of production systems of geographically dispersed SMEs or OEMs that collaborate in a shared value-chain to conduct joint manufacturing. Each member in the network produces one or more product component(s) that may be assembled into final service-enhanced products under the control of joint production schedule, while keeping its own autonomy. Production schedules are monitored collectively to accomplish a shared manufacturing goal. In dynamic manufacturing network, products are composed, (re-) configured and transformed on demand through dynamic and usually ad-hoc inter-organizational collaborations that can cope with evolving requirements and emergent behavior.



The three main phases of the DMN lifecycle, of which the **Network Analysis and Configuration** phase is the first, rely heavily on concepts and techniques found in the **Supply Chain Operations Reference model, short SCOR** model, which is promoted by the Supply Chain Council. Another important building block is the Standard for the Exchange of Product model data, short STEP, which provides a model for complete and unambiguous product definitions throughout the lifecycle of a product.

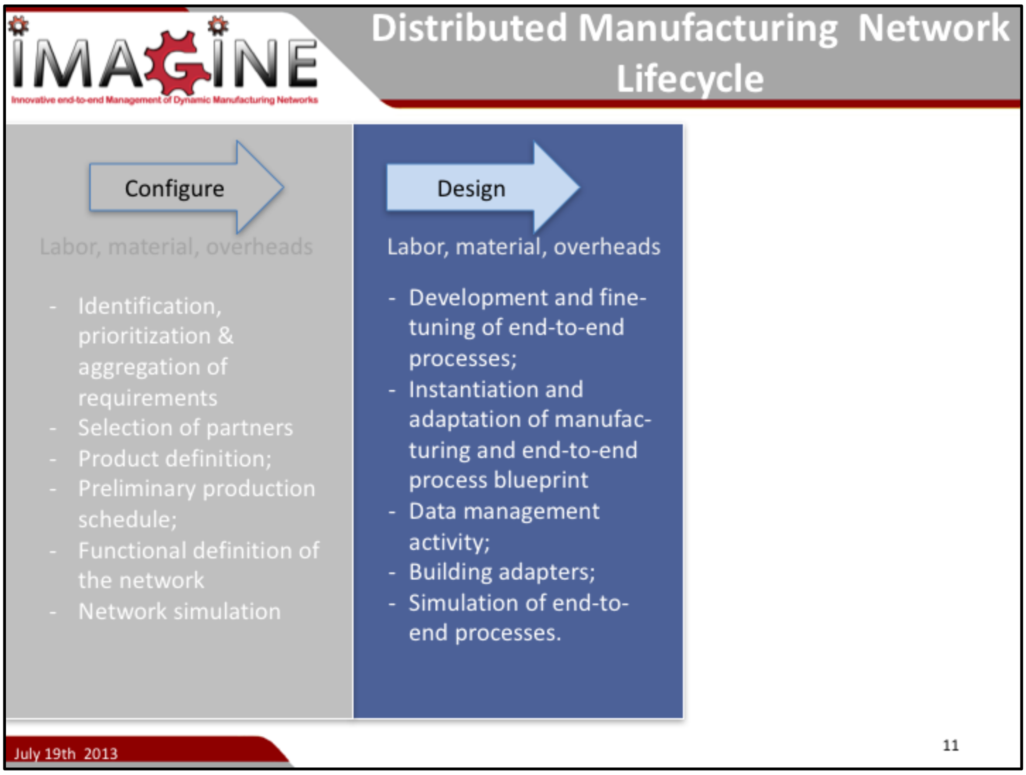
These three phases are preceded by an initial phase, called*: Administration and On-boarding,* in which material providers, suppliers, and parts manufacturers register in the integration or i-platform, which we will discuss a few more slides downstream. This way, the registrants advertise their capabilities, production capacity, products or services, and their availability. This information is used to identify matching network partners during initial network configuration or re-configuration during network operation when network partners need to be substituted or enforced.

Based on a given **customer request**, the first phase **Network Analysis and Configuration** consists of four steps:

Step-1: Production Order Management

Step-2: Creation of a High-Level Production Plan & Associated Schedule
Step-3: DMN Partner Search & initial Network Configuration
Step-4: Simulation and Baseline Network Configuration

Step 2 includes the elicitation of product and manufacturing requirements, their prioritization and aggregation and the definition of the product in terms of materials, components, qualitative and quantitative requirements
Step 3 requires the selection of proper manufacturing partners and the functional definition of the planned network. The network model can then be simulated in Step 4 to understand its intended behavior and adapt the baseline configuration if weaknesses are detected.



The second phase off the DMN lifecycle consists in the **Design of a Manufacturing Network.** The infrastructure required to support DMN manufactured products is typically complex. It requires a modeling and design strategy that supports the entire production system and flows - not only the physical product but its connection with its environment. By modeling the entire production network early in the DMN Lifecycle partners can simulate various product and architectural alternatives early in the development process when changes are much less expensive.
This phase involves the profile-driven design of manufacturing networks, providing control over processes and data content delivered by diverse network participants, including stipulating network performance, accessibility, resource utilization, and more. Aim of this phase is the design of a manufacturing network comprising well-defined standard end-to-end processes, the movement of product information and material exchanges between processes, as well as KPIs that govern the execution of processes.

This phase takes as input the configuration layout of the DMN and the preliminary schedule generated in the pervious phase as a starting point for the design of detailed end-to- end manufacturing processes in two basic steps:

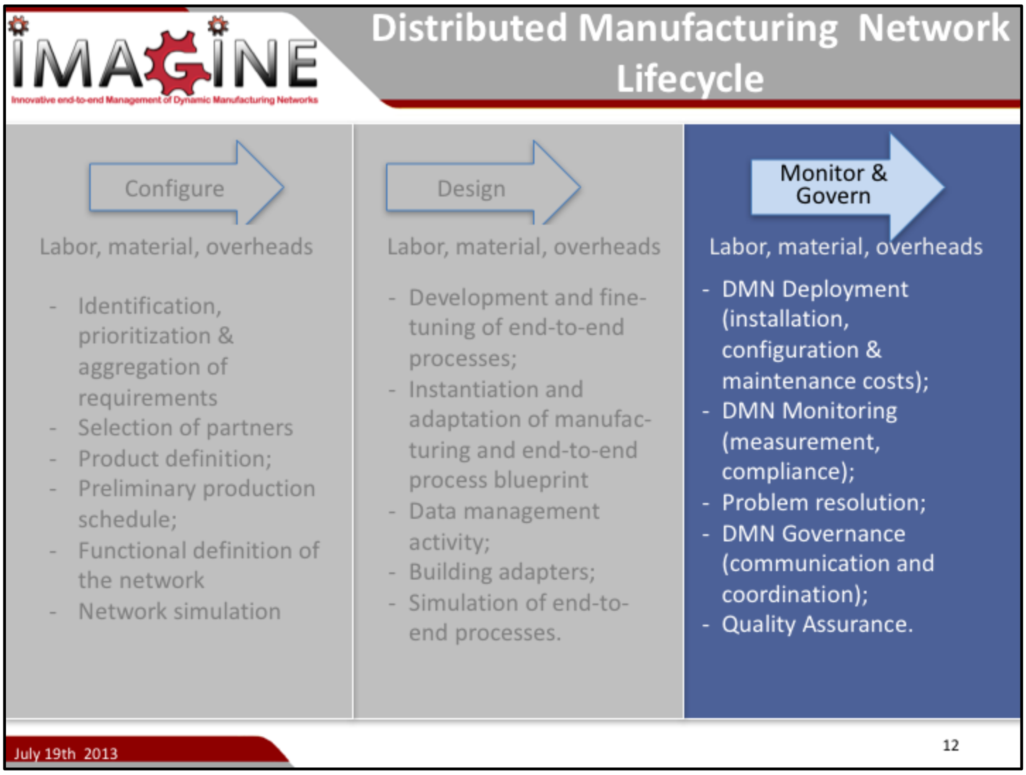
Step-1: Creation of a Detailed Production Schedule

Step-2: Choreography and Orchestration of

Production Processes Across the Network

The steps of this phase aim to understand the manufacturing network as a whole through modeling and simulating the network model prior to its execution to mimic actual operating conditions and evaluate potential improvements and benefits. Service technology is suggested by the project as an underlying operational mechanism that can accelerate this undertaking by coordinating and synchronizing resources and materials; routing tasks to people; machines and backend business IT systems; integrating data across the stovepipes; responding to events; and monitoring process performances.

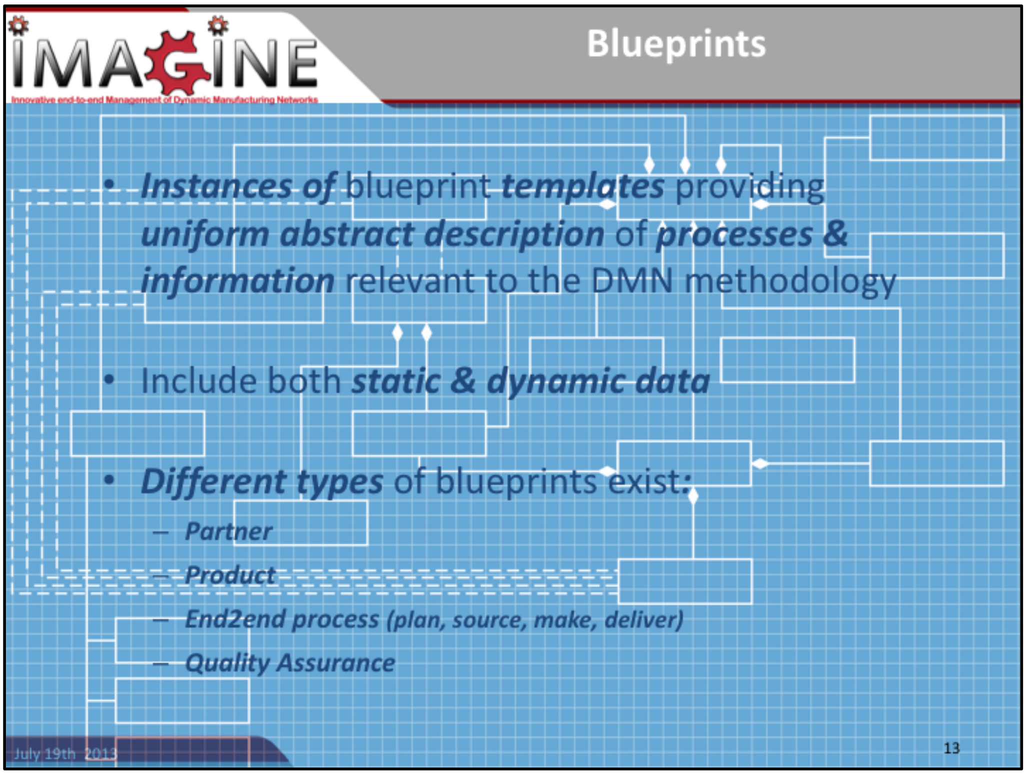
The process choreography in Step 2 specifies the exact relationships between DMN participants, interaction sequences between participants, such as the information and material flows between participants in the network, and the overall performance KPIs for the choreography. It does not yet specify how the coordinated interactions between network partners are implemented. The process orchestration will subsequently add more detail for each of the nodes in the choreography for the perspective of individual network partners



Phase 3 of the lifecycle model in concerned with Execution Management, Monitoring of the DMN and Production Operations, and Trouble-shooting activities if the network operation is disturbed.

From a management perspective, this phase involves the realization and deployment of the manufacturing network designed in the previous phase and the monitoring of its execution. During execution it is important to detect abnormal conditions, machine failures or KPI deviations as early as possible. The dynamic nature of these networks also requires a timely and consistent adaptation to changing consumer demands, laws and regulations (e.g., carbon emission) as well as rapid reaction to production bottlenecks or failures.

This phase must also track the use of resources and execution results to report on material consumption, labor utilization, equipment utilization, completion of customer orders, and other important measures of manufacturing performance.



To support the manufacturing network lifecycle, IMAGINE proposes a model-based approach, called its blueprint model. This model gathers, consolidates and integrates manufacturing data and processes from firms in a manufacturing network. A blueprint is an instance of a standardized template capturing agreed knowledge about enterprise resources, product life cycles, supply chains, partner relationships, operational planning data, manufacturing process execution data, compliance, safety and other regulations.

A blueprint captures static information, i.e., information that can be defined when a template is instantiated and changes infrequently – if at all –, but it also includes dynamic information that is pulled at production time from enterprise information systems such as ERP or PLM (Product Lifecyle Management) software.

We distinguish 4 types of blueprints:

The **partner blueprint** captures key corporate information, unique skills, capabilities and other information that is accessible to potential network partners to the extent necessary for smoothly functioning dynamic manufacturing networks. Corporate information include: contact data, size, annual reports, financial growth, annual turn-over, or products and services. For the latter it is important to know types of product and services, markets, industry sectors, geographical region of production sites and more. Related to processes the partner blueprint records core processes and key process skill. Concerning human resources, the partner blueprint documents their skills, track records etc. To understand the potential of a partner beyond its current offers, the blueprint lists planned products and case histories of previous network collaborations. To enable the assessment of a partner's qualifications, information about standards and patents awarded, references to customers, and rating information are also provided in this blueprint. Finally fundamental cost information is recorded as well. Companies in a network should be able to provide and edit the data required by the IMAGINE DMN methodology and that is specified in the partner blueprint. Given the importance for the management of a company inside IMAGINE platform, IMAGINE platform will ensure that only users that have roles with the appropriate rights should be able to edit company data. Among other information companies will be able to define the various sites, departments and services of the organization, including geographical information and define the available resources, services, products and competencies that can provided. Access to company data and resources will also be restricted according to roles and permissions appointed to users by the company administrator.

The **product blueprint** defines the basic concepts necessary to assess whether a partner has the required capabilities in terms of human resources, material resource, machinery, and skills to join the DMN. This roughly corresponds to what is contained in a manufacturing bill of materials (short MBOM), which contains all the parts and assemblies required to build a complete and shippable product.This blueprint defines the process segment that could be carried out by a certain partner to achieve the production of a certain product. Thereby, the product blueprint sets up the constraints and the preconditions with respect to the construction of a product that a partner should respond to. This blueprint also environmental Information, such as CO2 footprints, greenhouse gas emissions, spills, and hazardous or non-hazardous waste.

End-to-end processes in manufacturing networks inherently cross functions, departments and actors within a manufacturing network. Bringing all of elements contributed by these players together under the umbrella of a single blueprint is critical to the operational performance of the DMN. The **end-to-end process blueprint** defines how actions are scheduled and executed, how decisions are made, and where responsibility is handed off between functions and partners. It also provides a more flexible and accurate description of equipment setup, materials acquisition, as well as activity control, information flow and materials flow. More precisely, the end-to-end process blueprint identifies four core processes that manage business rules, supply chain performance, data collection, inventory, planning configuration, process flows, regulatory and compliance requirements on the basis of vendor-neutral PLM product generation data:

- **Plan,** which talks about targets sourcing, manufacturing and delivery requirements and establishes plans for the whole product development.
- **Source**, which procures goods and services to meet planned or actual

demand and schedules deliveries, receives, verifies, and transfers products, and authorizes supplier payments. Here also supply source are identified and selected.

- **Make**, which transforms a product to a finished state to meet planned or actual demand.

- **Deliver**, which provides all order management steps from processing customer enquiries and quotes to routing shipments and selecting carriers.

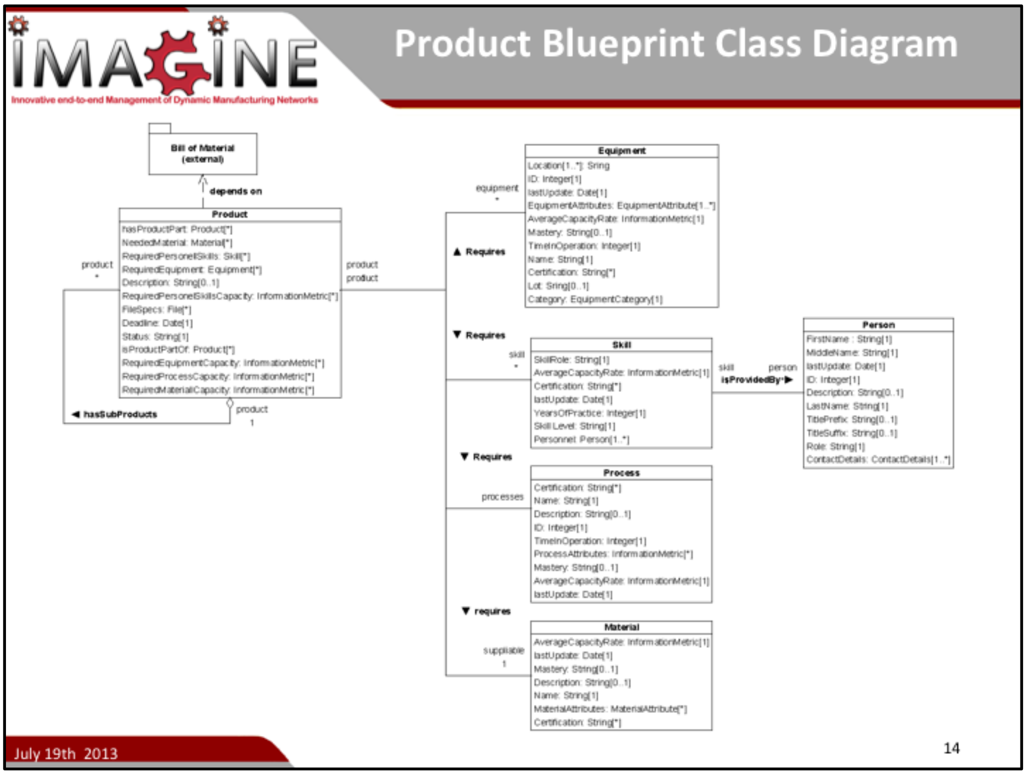
Quality management is an indispensible facet of production management and, like the end-to-end-process, it is a cross-cutting concern that requires other metrics than the mere departmental ones used in today’s manufacturing operations management. The **Quality Assurance blueprint** maintains precise management control of mission-critical information for key manufacturing and production parameters. This blueprint contains a collection of metrics for operations analytics and activity-based metrics for manufacturing operations, logistics, and costing, including:

- **Production Schedule Information**, which tells us the products to be made, what production start or completion times are, and which resources in terms of personnel, equipment, and material will be needed.
- **Production Performance KPIs,** which are defined in terms of equipment, and material used per production segment, per product or scheduled item.
- **Environmental KPIs.**

The innovation affected by these blueprint is that all information needed for managing network-based manufacturing processes is:

- made explicit using a controlled terminology,
- structured in a predefined way defined by blueprint templates, and can be
- refined in a systematic manner using a standardized modeling notation (UML).

This enables an automated data retrieval and exchange between network partners' IT systems.

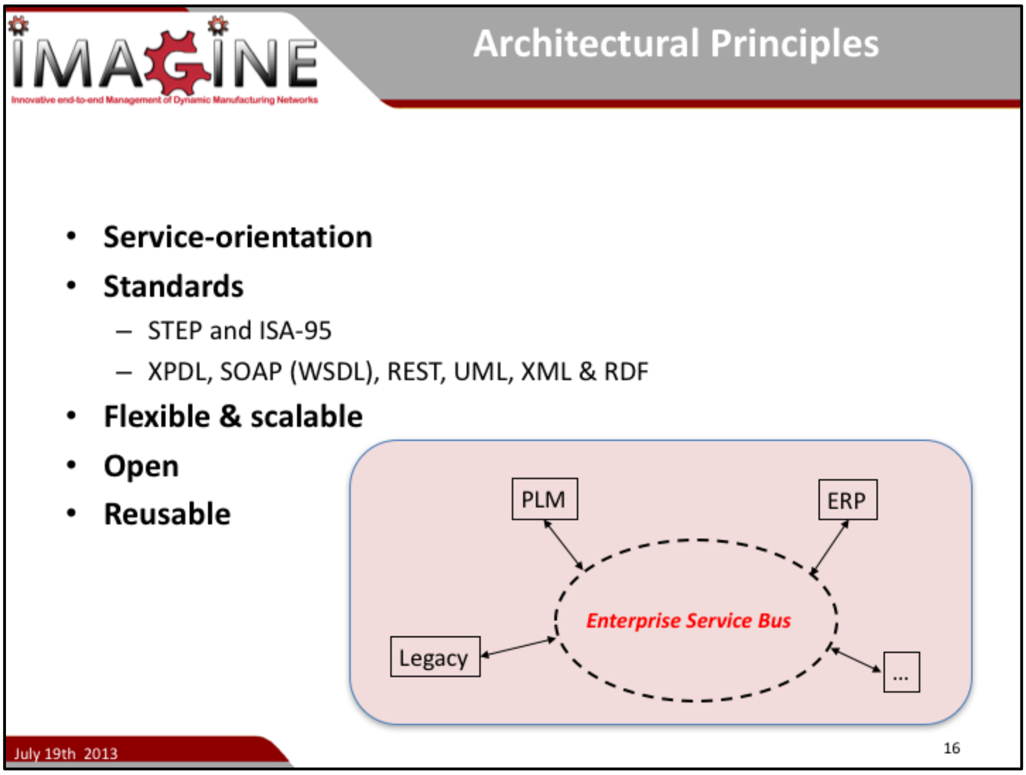


This class diagram illustrates which information is represented in a product blueprint whose details are derived from a given bill of materials. It includes a hierarchical definition of the product based on its composition of parts – on the left. At each part and composition level the materials needed to produce that part or composite product, the skills of production personnel, necessary equipment and capacities needed and other data are maintained. The classes on the right further elaborate on the details of equipment information, skills, processes and material referred to in the product definition.

Similarly, the other blueprints are defined both interms of UML, the Unified Modeling Language, and RDF, the Resource Description Fframework, which was standardazid by the World Wide Web Consortium for describing metadata.

i_Platform Architecture

- Design Principles
- Components
- Interfaces



In addition to presenting a new methodology for managing dynamic manufacturing networks and a blueprint model to capture all information necessary to support the execution of his methodology effectively, IMAGINE has also developed a generic integration platform, called i_platform, that supports all phases and activities of dynamic manufacturing network management.

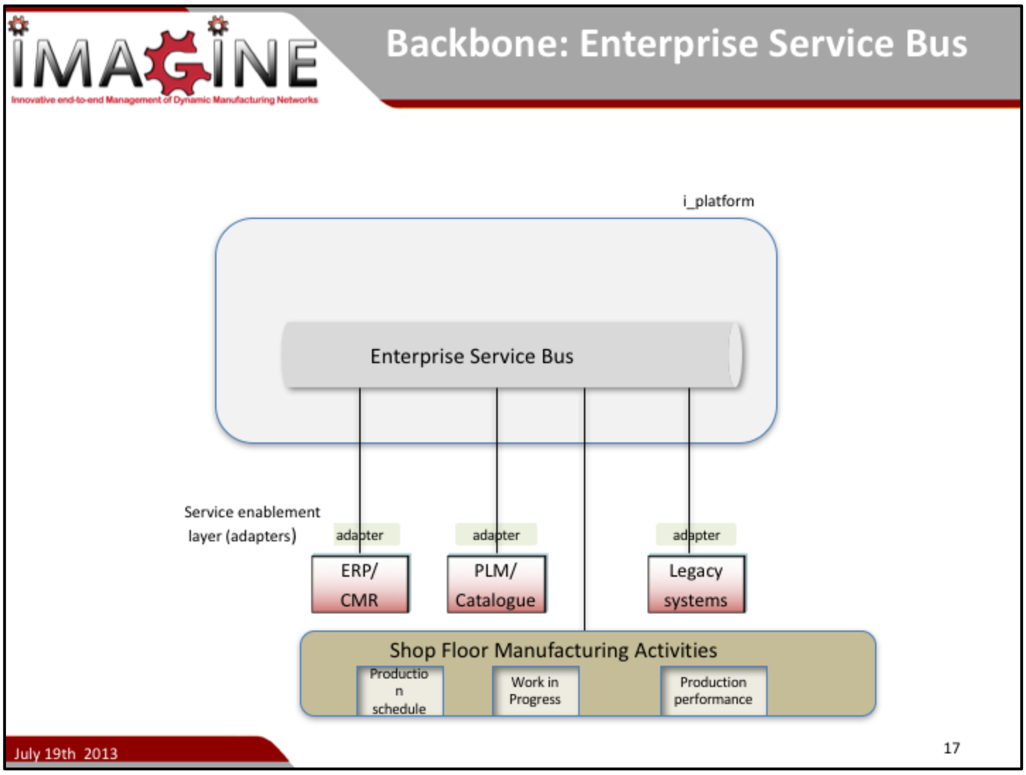
The architecture of the iplatform is **service-oriented**. Services provide a simplified mechanism for connecting manufacturing applications regardless of their location or the technology, equipment or devices they use. The backbone of the i_platform is an Enterprise Service Bus, ESB fro short. The ESB is the central point of integration. Network partners can build service adapters to their applications in a highly granular fashion and plug these service components into the service bus that takes care of their interoperation. Thus, network partners can easily interact with customers, suppliers, and partners in a dynamic manufacturing network over the Internet.

The architecture of the iplatform was designed taking into account global manufacturing **standards**, notably, STEP and ISA-95, and implementation standards such as XPDL, SOAP (WSDL), REST, UML, XML and RDF.

The architecture is designed as an **open architecture** that allows new and legacy tool components – proprietary or open source – to be plugged into the IMAGINE Enterprise Service Bus.

The architecture addresses the need for dynamic changes and scalability with respect to workloads through replication of tool components without disrupting other tool components.

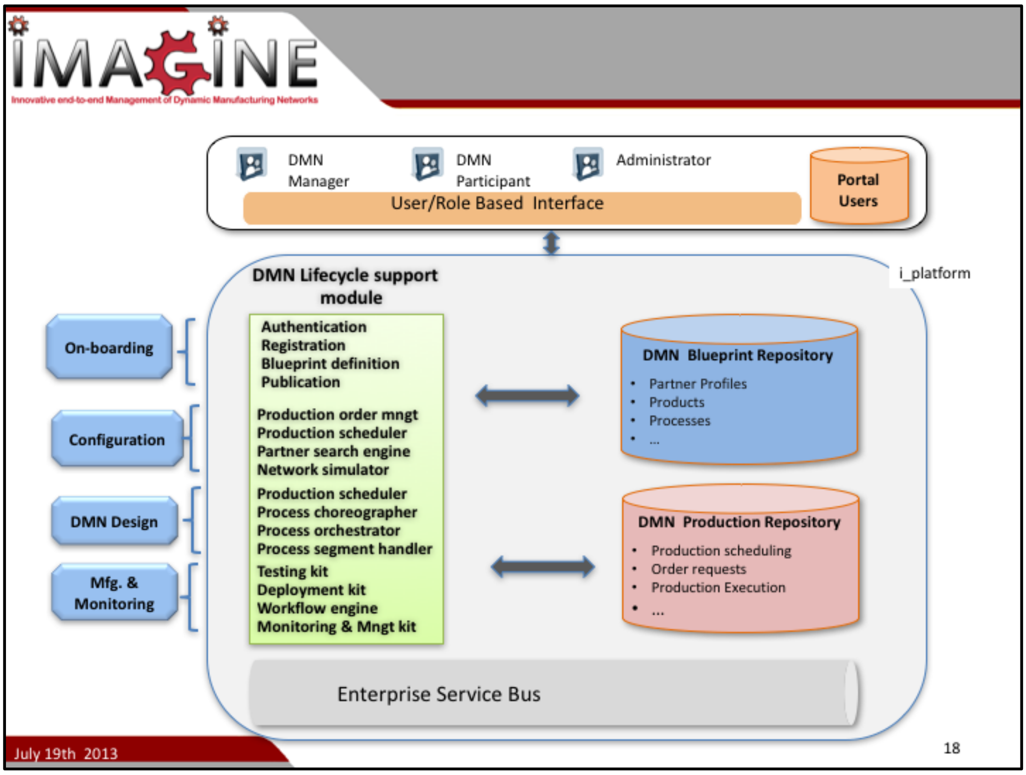
The iplatform architecture promotes reuse at all levels allowing bottom-up development with proprietary or open-source components.



The iplatform aims to integrate material providers, suppliers, and parts manufacturers with Original Equipment Manufacturers from the management perspective addressing all aspects of manufacturing from plant operations to the supply chain.

The Enterprise Service Bus (ESB for short) is the central component of the IMAGINE platform. An ESB comprises a set of infrastructure capabilities implemented by middleware technology. They enable a service-oriented approach to manufacturing and alleviate disparity problems between applications that run on heterogeneous platforms of different network partners and use diverse data formats. The ESB functions as transport and transformation facilitator to allow distribution of services and communication of data over disparate application and computing systems. Examples include ERP, CRM, PLM and other systems that provide management relevant information about manufacturing processes. Conversely, shop-floor application operations rely on manufacturing operations management functions such as dispatching, route execution, or alarm and event handling.
These applications are not part of the ESB but are connected to it through application-specific adapters.

Let us now dissect the interior of the iplatform and explain further important building blocks of the platform.



On top of the ESB, the iplatform offers a range of tools supporting DMN the lifecycle management phases. These tools especially support the activities of the DMN lifecycle management phases.

For the onboarding phase we have tools to manage the authentication and registration of new firms who want to join the e-marketplace and eventually participate in manufacturing networks. New members of the marketplace can them define their profiles, products and capabilities using proper blueprint templates and then publish them, while existing marketplace members can use the blueprint definition tool to update their corporate data. The blueprint templates and member-specific blueprints are maintained in a blueprint repository, which comes with appropriate search, browse, save functionality. This repository contains partner blueprints with corporate profiles, product blueprints, which inform about the members product catalog, process blueprints, work definition & schedule templates, work plans, and resource specifications including machinery and human resources.

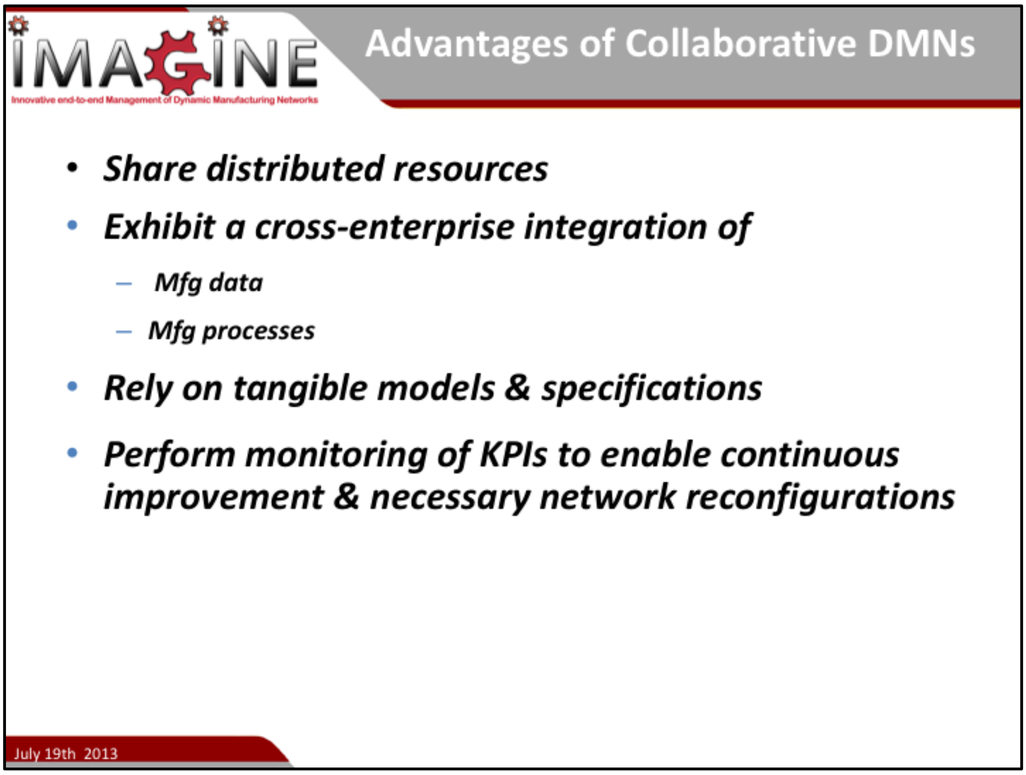
The activities of the configuration phase are supported by tools that help managing production orders, specify production schedules, match partner searches with partner and product blueprints available in the e-marketplace, design a partner network and simulate it. Information created and used in this and subsequent phases is managed with the help of a DMN production repository. It keeps track of production scheduling, order requests, production execution, bills of materials, assembly instructions, and more.

To support the tasks of the DMN design phase, a range of tools to design and implement production processes on top of company-specific process segments are offered.

Finally, for testing fully defined manufacturing processes, monitor manufacturing processes under execution, identify hazards and problems, and match monitoring data with KPI specifications, appropriate tools are available.

The iplatform is also equipped with a web portal that provides end-users with a single dedicated, personalized point of access to relevant and authoritative information. A variety of stakeholders, including Network Manager, Product Engineer, or Production Planner, and others obtain access to iplatform resources on the basis of access rights and business rules precisely defining their role and responsibilities. For instance, the Network Manager has the ability to:

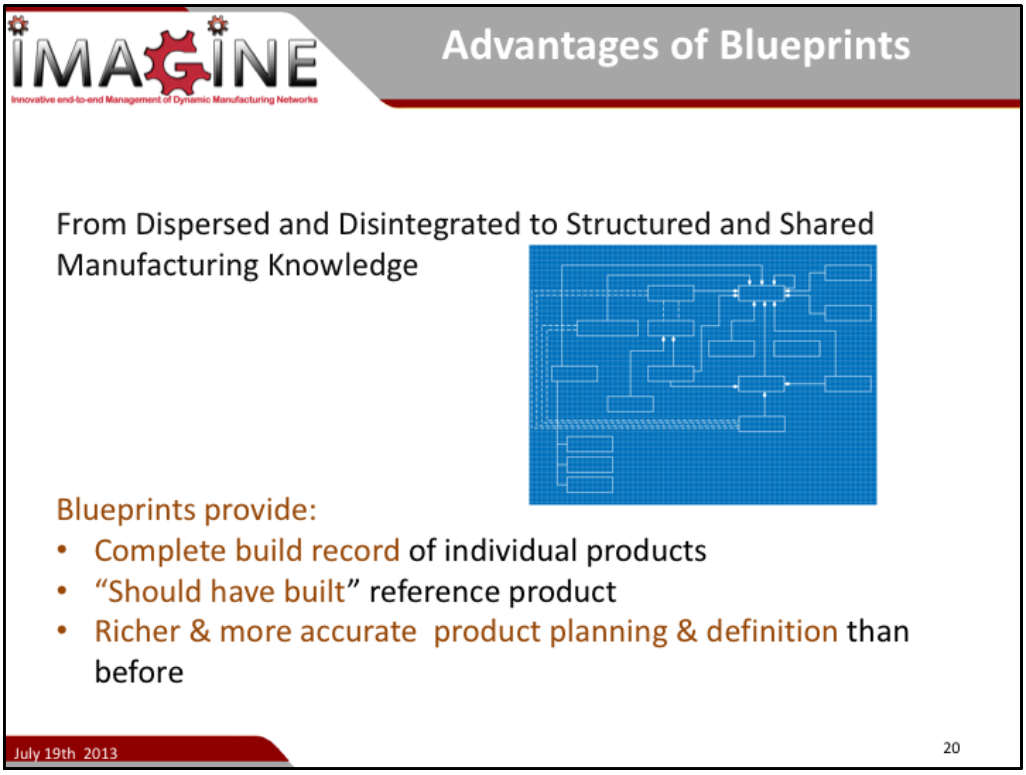
- Create and configure a specialized manufacturing network by identifying core partner competencies and resources, specific product/service offerings, shop-floor facilities and personnel that need to be tailored to achieve the desired objectives.
- Take into account the capacity of production lines and focus on the efficiency of the production process.
- Shape and align manufacturing processes to ensure that greater efficiency and control are applied over them to achieve better utilisation of all available assets across multiple enterprises.
- Ensure that participating firms' business processes are visible only to relevant partner groups along the manufacturing network and that partners have the ability to act on information that is securely available to those with appropriate privilege levels.



Sharing of distributed resources and combination of complementary competencies, which are core matters of production networks, helps to reduce cost and production time. The flexibility of dynamic networks whose nodes are drawn from a constantly growing and changing e-marketplace in addition provide the ground for product and production innovations

Cross-enterprise integration of manufacturing data and processes paired with modeling, simulation and monitoring capabilities brings about tangible models that can be analyzed, simulated, and continuously improved to:

- Increase flexibility in manufacturing,
- Optimize production rates,
- Customize production faster.



The Blueprint model manages and cross-correlates segregated manufacturing knowledge about increasingly complex products comprised of machines, equipment, workplaces, personnel with unique configurations that pertain to different product models and different market segments. It includes:

- A complete build record of individual products as assembled constructed and operated, product deviations, traceable components, equipment, materials, systems and environmental compliance.
- "Should have built" reference product structures that can be used to verify the assembled product.
- Schematized, richer and more accurate

product planning and definition throughout the manufacturing lifecycle.

It defines a product as work-plans, parts lists, end-to-end processes, recipes, process instructions & data sets that arise during product development.

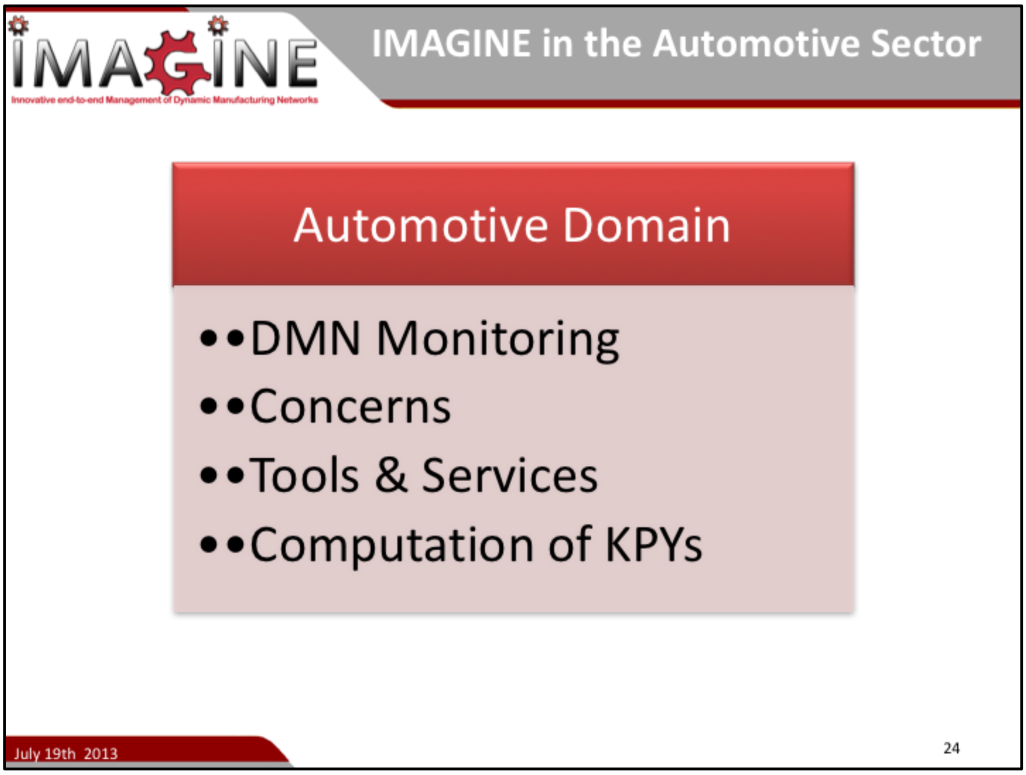
We can summarize the innovations intended by the methodological and technological contributions of the IMAGINE project from the perspectives of manufacturing and product lifecycle management.

Innovations in Manufacturing

From	To
Autonomous & dedicated production facilities designed for low product mix & economies of scale	Active demand shaping to level load, supply sensing, design for mfg in collaborative manufacturing networks
Enterprise-driven design, focus on optimized engineering, unstructured prioritization of projects	Collaborative, market-driven design and simulation aligned with strategic business initiatives

Innovations in PLM

From	To
New products introduced in silos, independent of previously launched products	Products/brands introduced as platforms to deliver extended features & services & reduced product cycles.



In the next few slides we consider a the automotive domain and focus on the third phase of the DMN management lifecycle: the monitoring phase, which supports governing running manufacturing processes. First, specific concerns and management contributions of the monitoring task are addressed. Then a concrete monitoring tool, Nagios, is introduced, including its functions and components. To interface the monitoring tool with existing management infrastructure an extension to Nagios in the form of two web services is described. This section concludes with a reference to key performance indication that are calculated on the basis of such monitoring data.

Monitoring of a Dynamic Manifacturing Network (DMN) (1/3)

Typical questions for a DMN Manager:

- Has manufacturing started on time?
- Is the DMN producing according to plan?
- Has the required production process event occurred on time?
- Will the order adhere to schedule and ship on time?
- Does this order meet our On-Time Delivery Goal and quality KPIs? If not, why not?
- What % of completions were scrapped and reworked?
- What are the bottlenecks in the current production process?
- How much revenue was lost due to rework and scrap?

Dynamic monitoring methodology will provide an instrument to support managers to effectively and easily answer these questions

Monitoring of a Dynamic Manifacturing Network (DMN) (2/3)

Monitoring of a DMN: what does it mean?

- Track real-time information of the production process (material movement, consumption, asset, resource utilization)
- Push shoop floors data to a single central unit
- Catch synchronous/asynchronous events (e.g. product delivered on time)
- Aggregate data for KPI (Key Performance Indicator): transform raw data into information suitable for analysis
- Store data in databases to be accessible by production management analytics tools

IMAGINE
Innovative end-to-end Management of Dynamic Manufacturing Networks

Monitoring of a Dynamic Manifacturing Network (DMN) (3/3)

Which are the advantages?

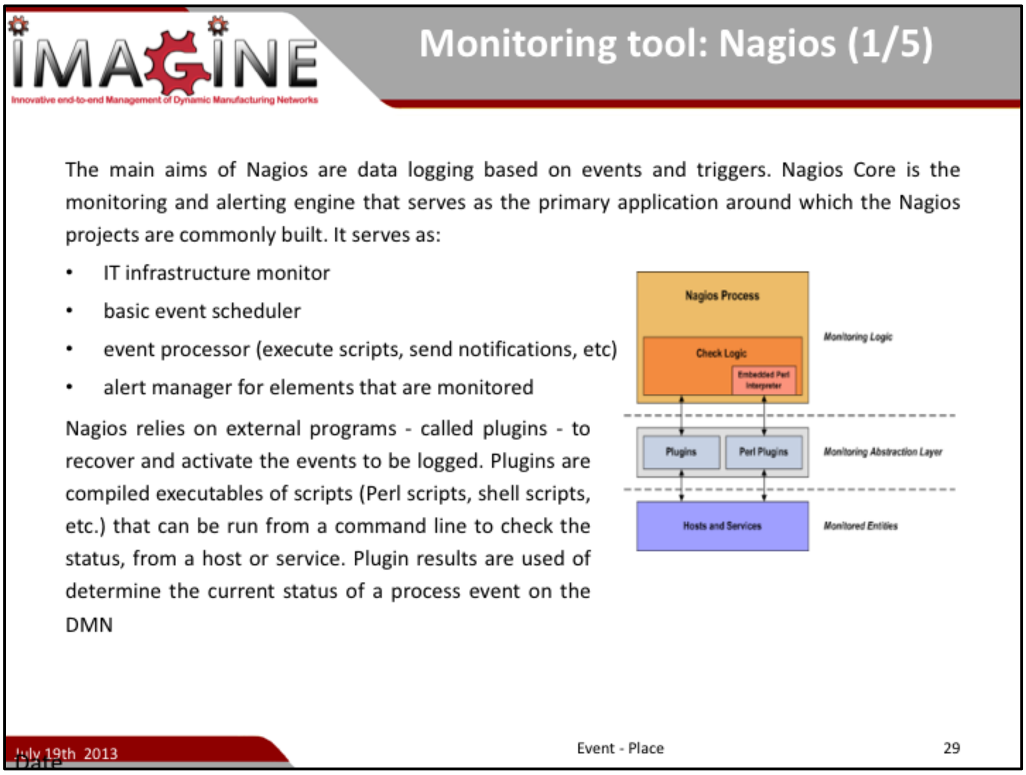
- Control and transparency of the entire production process → wide-ranging view of a DMN's production and performance
- Real-time awareness about situations of interest (real-time detection of monitored patterns)
- Efficient approaches to understanding changes' impact on the whole DMN process
- Mechanisms for sensing changes (internal and external context): proactive identification of potential issues and continuous refinement of the monitoring goals
- Support for DMN Managers and factory-based employees in making improved decisions

The monitoring tool chosen for the IMAGINE platform is the open source **Nagios**.

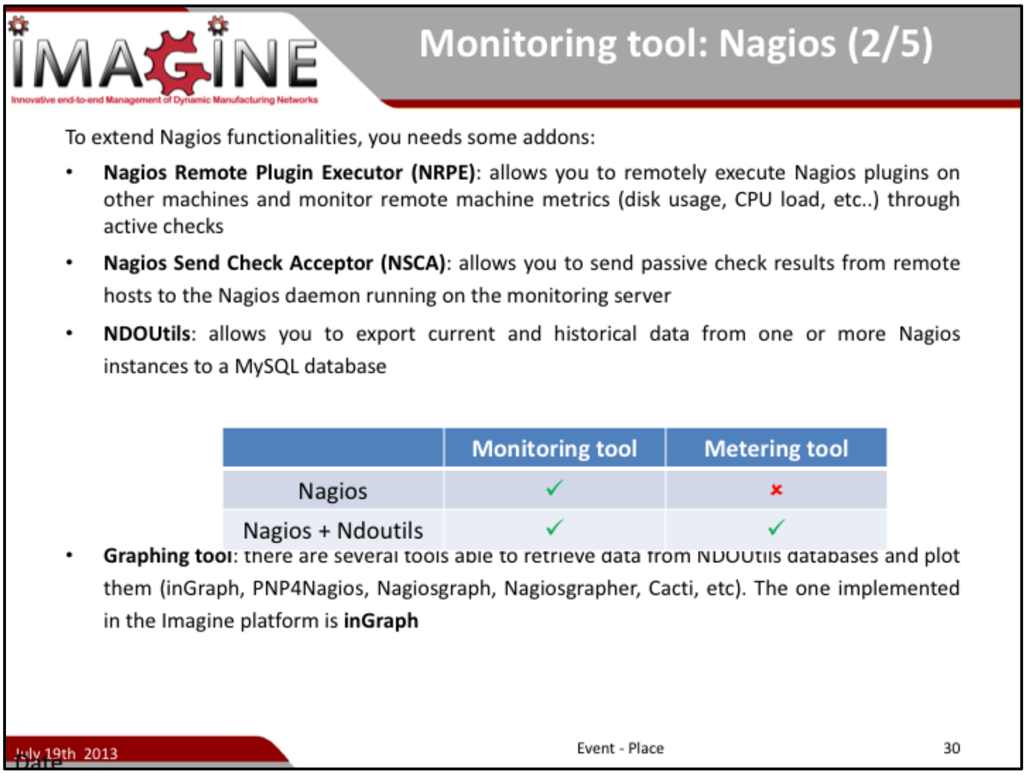
The scope of Nagios is primarily focused on:

- Monitoring an IT infrastructure;
- Handling events;
- Rising alerts up;
- Sending notifications;

The documentation about Nagios project http://www.nagios.org/



Nagios will execute a **plugin** whenever there is a need to check the status of a host, machinery, file system, service or process event.
The plugin performs the check and then simply returns the results to Nagios; Nagios will process the results that it receives from the plugin and take any necessary actions (running event handlers, sending out notification, logging data, comparing this to thresholds etc).
Plugins act as an **abstraction layer between the monitoring logic present in the Nagios daemon and the actual processes from DMN being monitored**.



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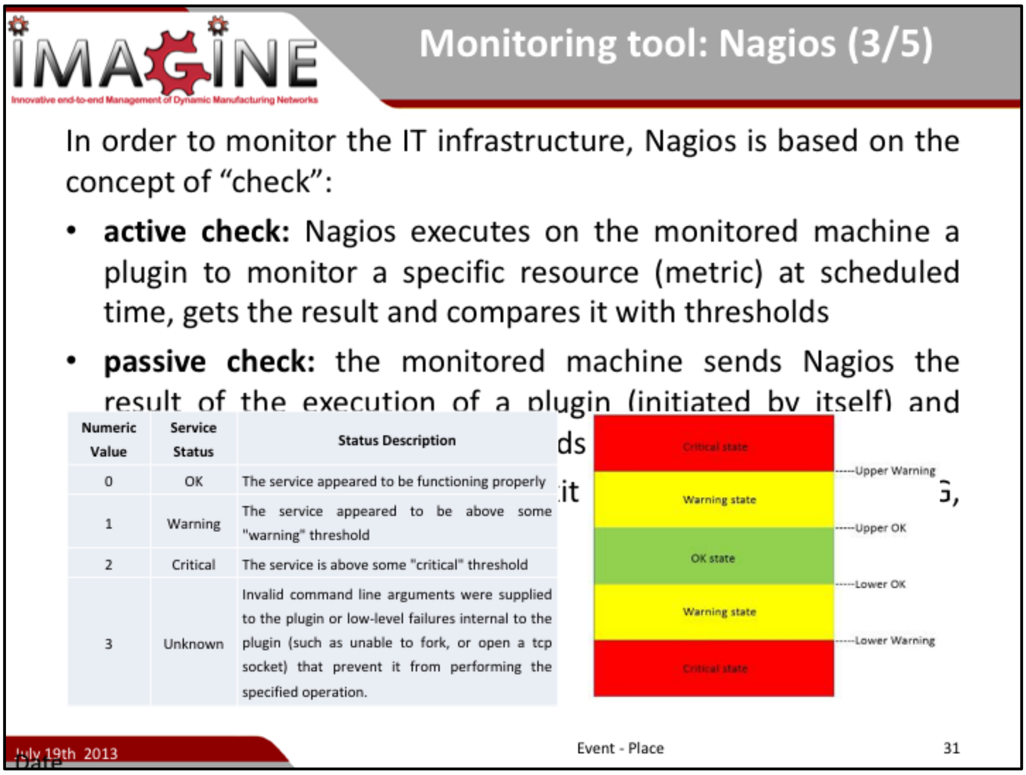

Numeric Value	Service Status	Status Description
0	OK	The service appeared to be functioning properly
1	Warning	The service appeared to be above some "warning" threshold
2	Critical	The service is above some "critical" threshold
3	Unknown	Invalid command line arguments were supplied to the plugin or low-level failures internal to the plugin (such as unable to fork, or open a tcp socket) that prevent it from performing the specified operation.

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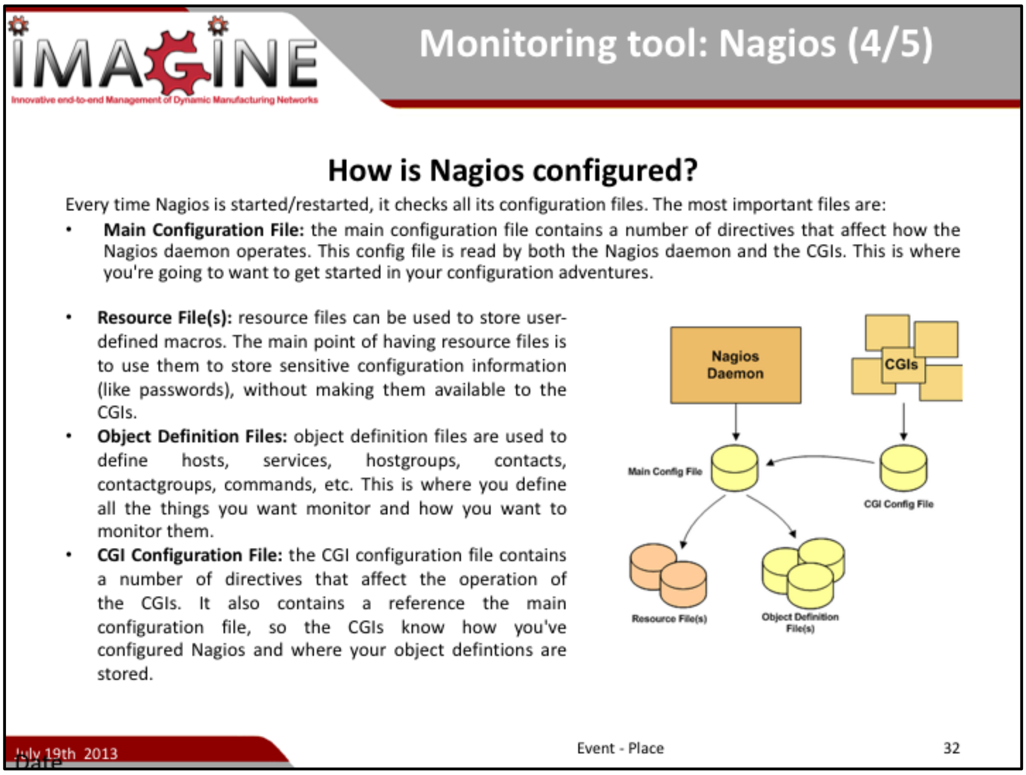

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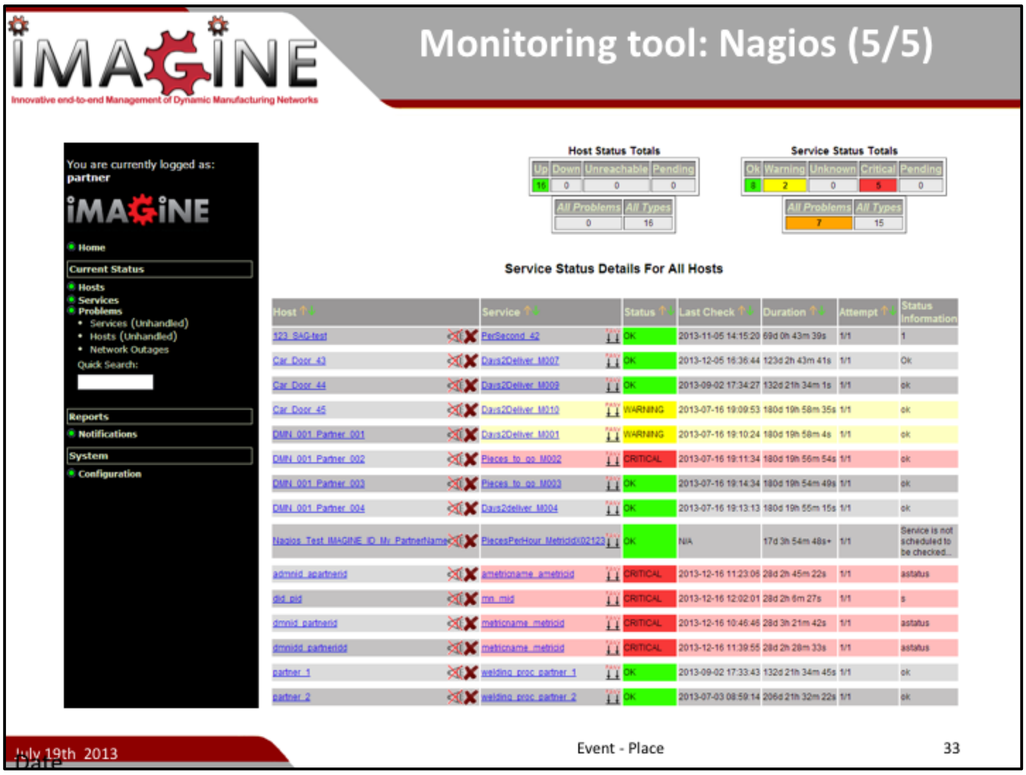

Screenshot of the Nagios Web Interface

Monitoring tool in IMAGINE (1/5)

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Monitoring tool in IMAGINE (3/5)

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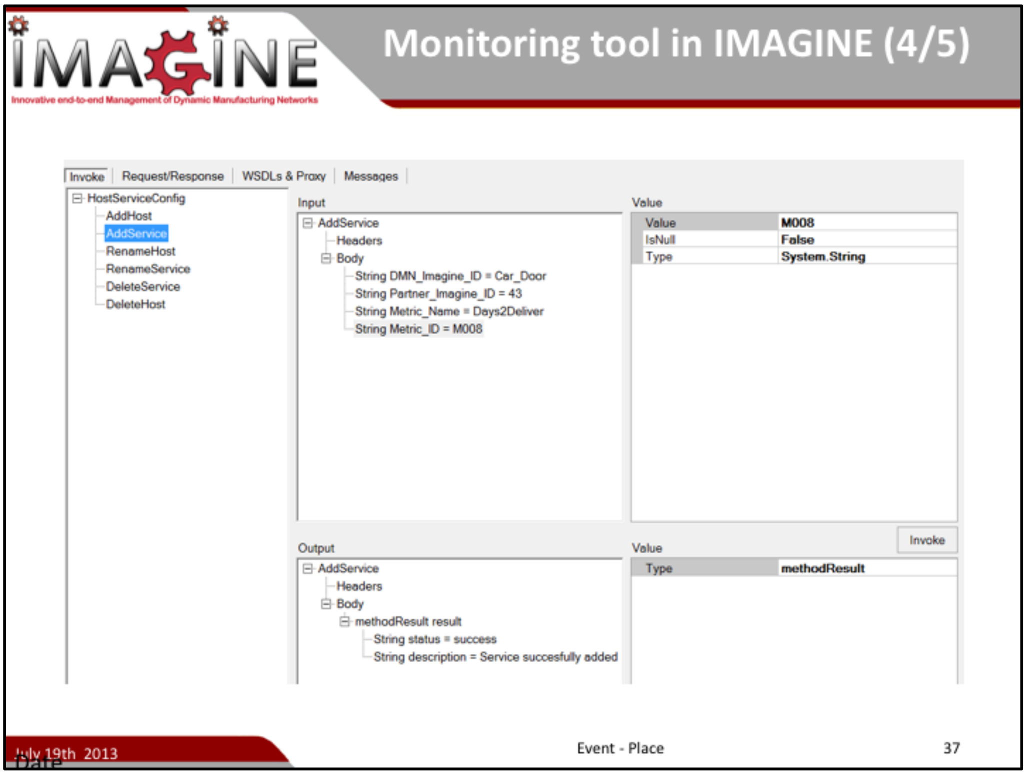

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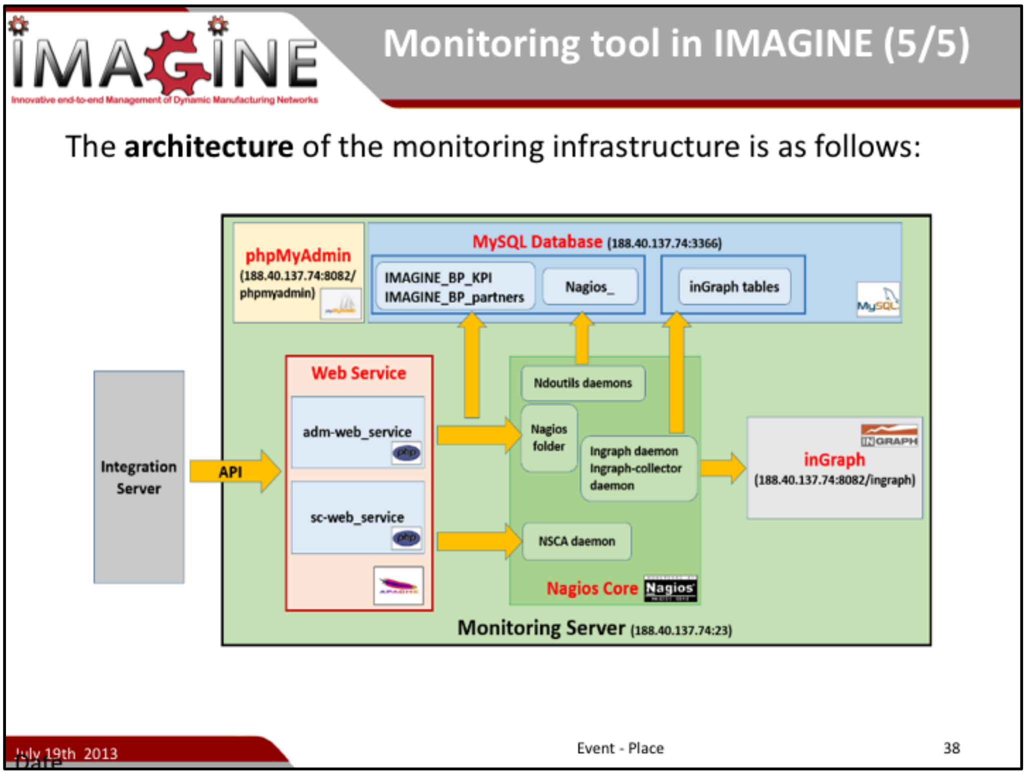

For a detailed description of each MySQL table, please refer to deliverable D3.1.2

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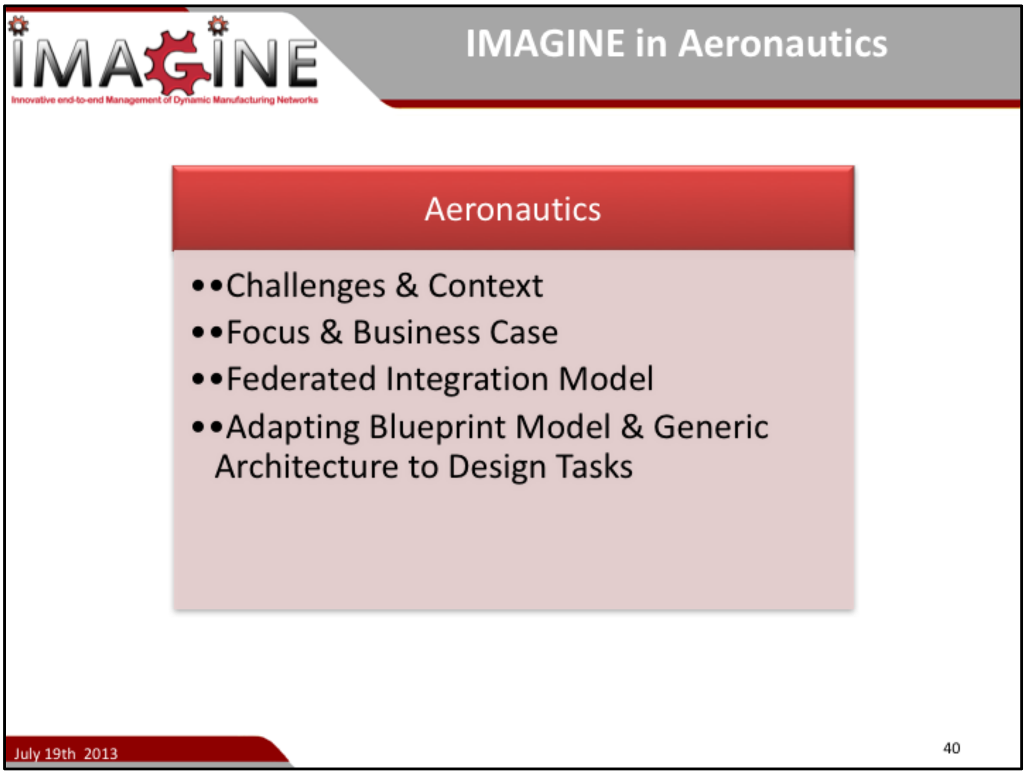


In this section we illustrate how the DMN methodology can be adapted to product design rather than manufacturing. To begin with, we described the challenges IMAGINE helps to address in this domain. We discuss to what extent the DMN process needs to be customized and how IMAGINE contributions are positioned to support concrete business cases in this application domain. Then various facets of methodology, generic architecture and blueprint customization are presented.

Monitoring of a Dynamic Manifacturing Network (DMN) (1/3)

Typical questions for a DMN Manager:

- Has manufacturing started on time?
- Is the DMN producing according to plan?
- Has the required production process event occurred on time?
- Will the order adhere to schedule and ship on time?
- Does this order meet our On-Time Delivery Goal and quality KPIs? If not, why not?
- What % of completions were scrapped and reworked?
- What are the bottlenecks in the current production process?
- How much revenue was lost due to rework and scrap?

Dynamic monitoring methodology will provide an instrument to support managers to effectively and easily answer these questions

Monitoring of a Dynamic Manifacturing Network (DMN) (2/3)

Monitoring of a DMN: what does it mean?

- Track real-time information of the production process (material movement, consumption, asset, resource utilization)
- Push shoop floors data to a single central unit
- Catch synchronous/asynchronous events (e.g. product delivered on time)
- Aggregate data for KPI (Key Performance Indicator): transform raw data into information suitable for analysis
- Store data in databases to be accessible by production management analytics tools

Monitoring of a Dynamic Manifacturing Network (DMN) (3/3)

Which are the advantages?

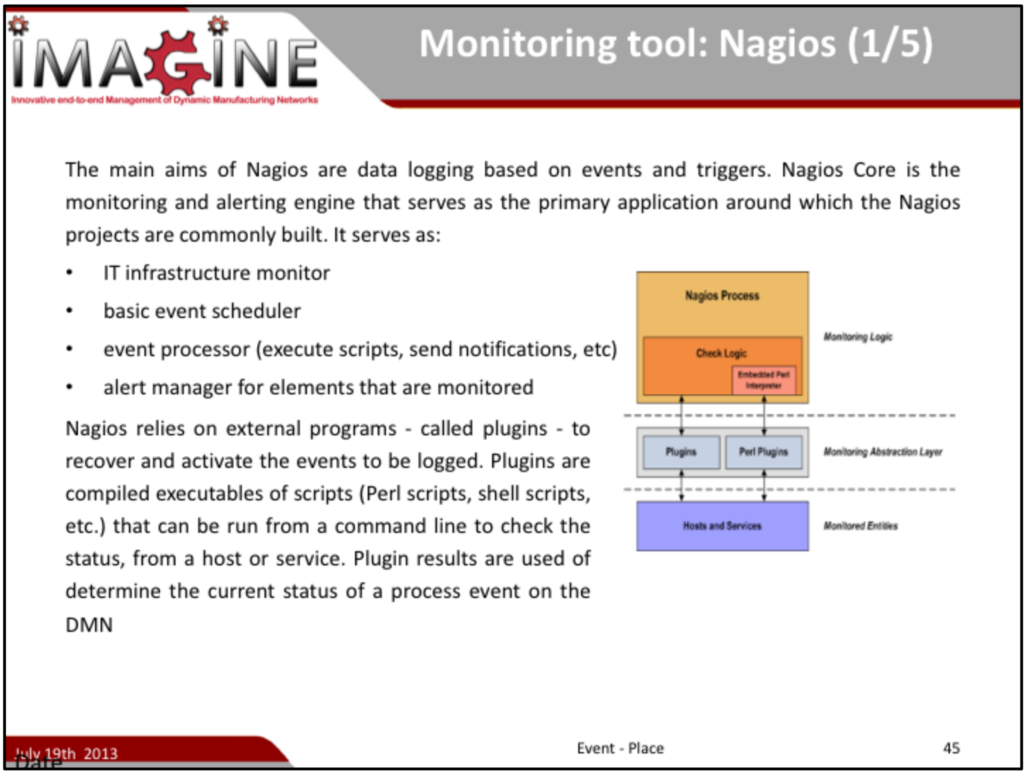
- Control and transparency of the entire production process → wide-ranging view of a DMN's production and performance
- Real-time awareness about situations of interest (real-time detection of monitored patterns)
- Efficient approaches to understanding changes' impact on the whole DMN process
- Mechanisms for sensing changes (internal and external context): proactive identification of potential issues and continuous refinement of the monitoring goals
- Support for DMN Managers and factory-based employees in making improved decisions

The monitoring tool chosen for the IMAGINE platform is the open source **Nagios**.

The scope of Nagios is primarily focused on:

- Monitoring an IT infrastructure;
- Handling events;
- Rising alerts up;
- Sending notifications;

The documentation about Nagios project
http://www.nagios.org/



Nagios will execute a **plugin** whenever there is a need to check the status of a host, machinery, file system, service or process event.
The plugin performs the check and then simply returns the results to Nagios; Nagios will process the results that it receives from the plugin and take any necessary actions (running event handlers, sending out notification, logging data, comparing this to thresholds etc).
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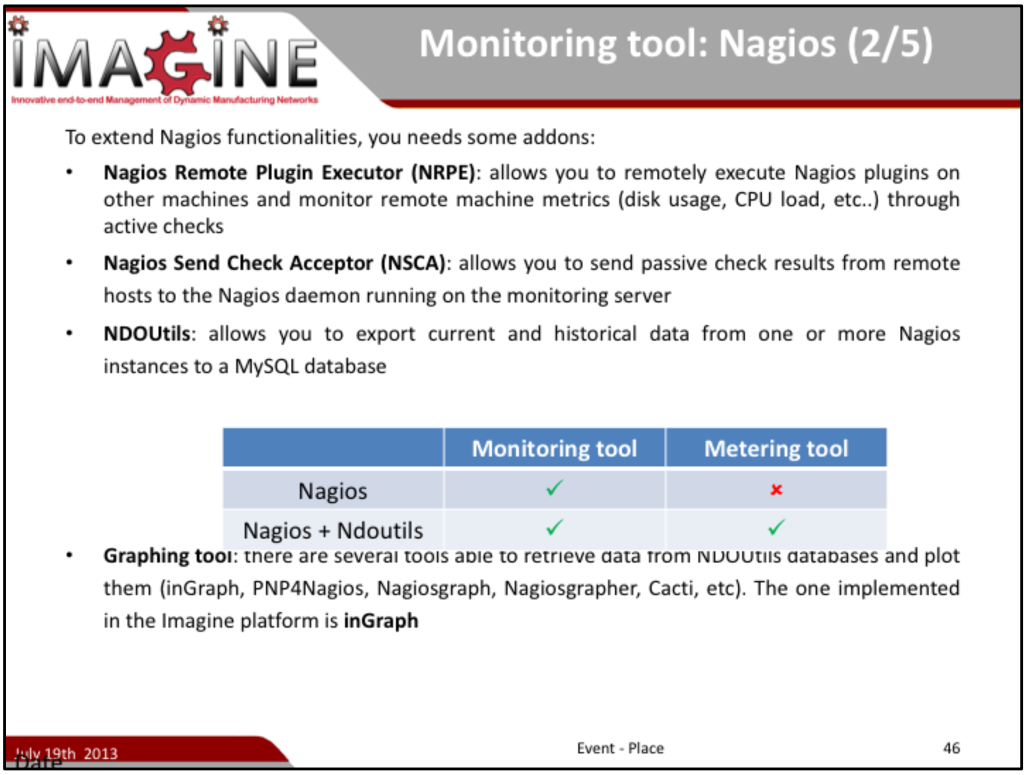

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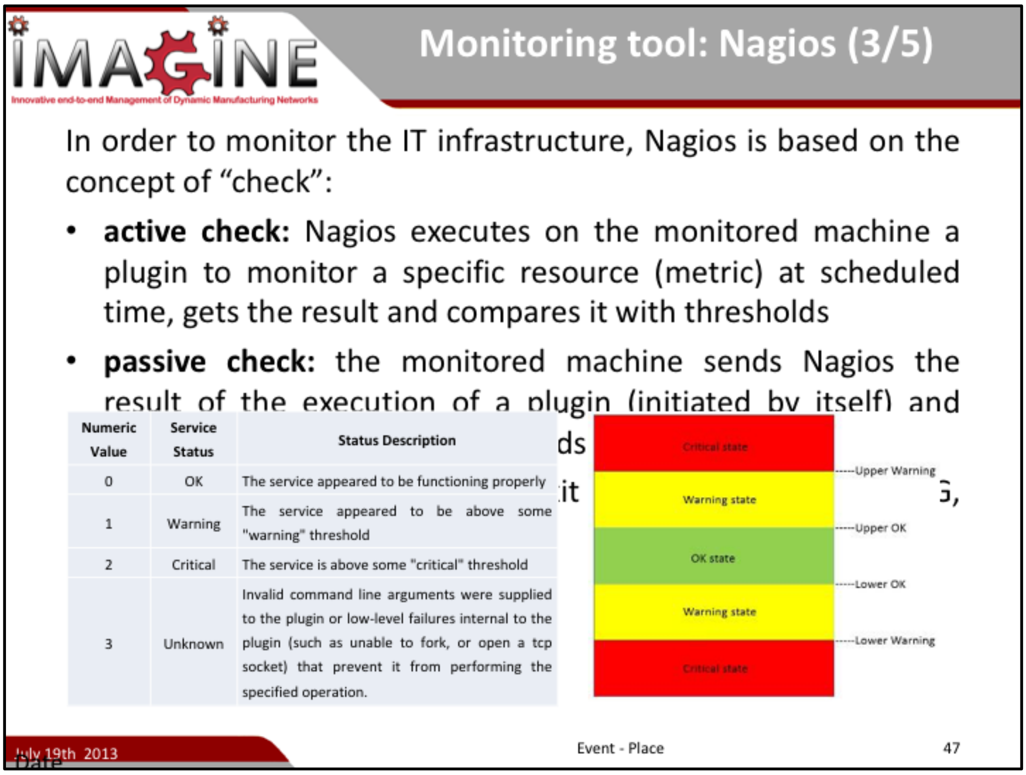

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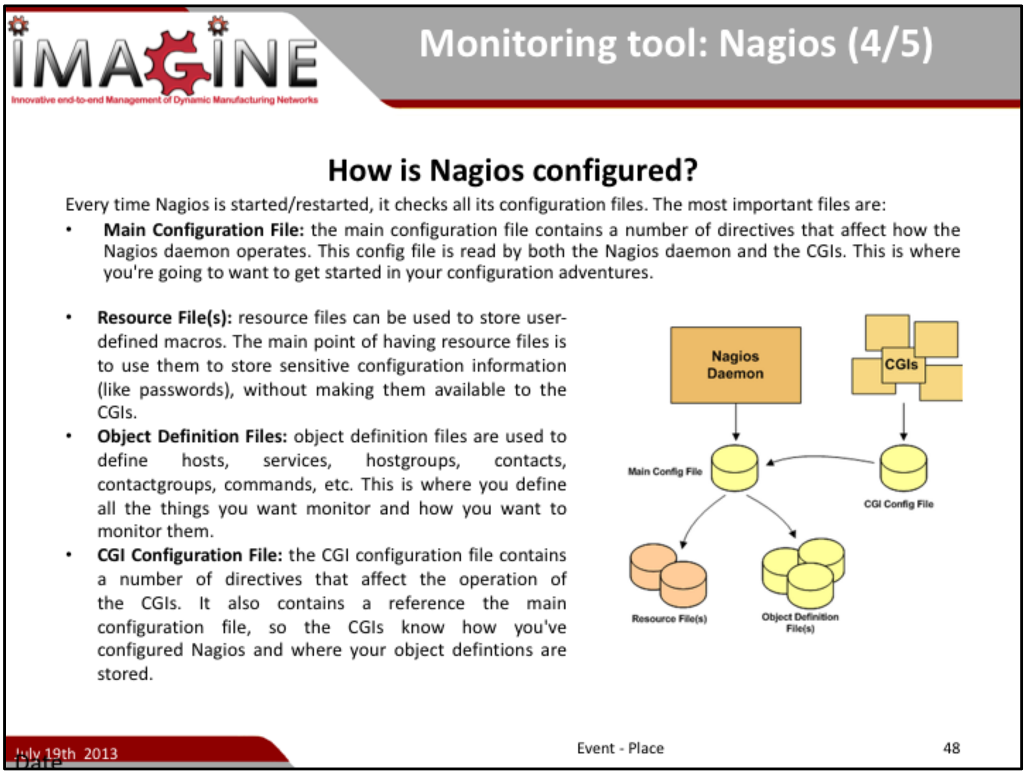

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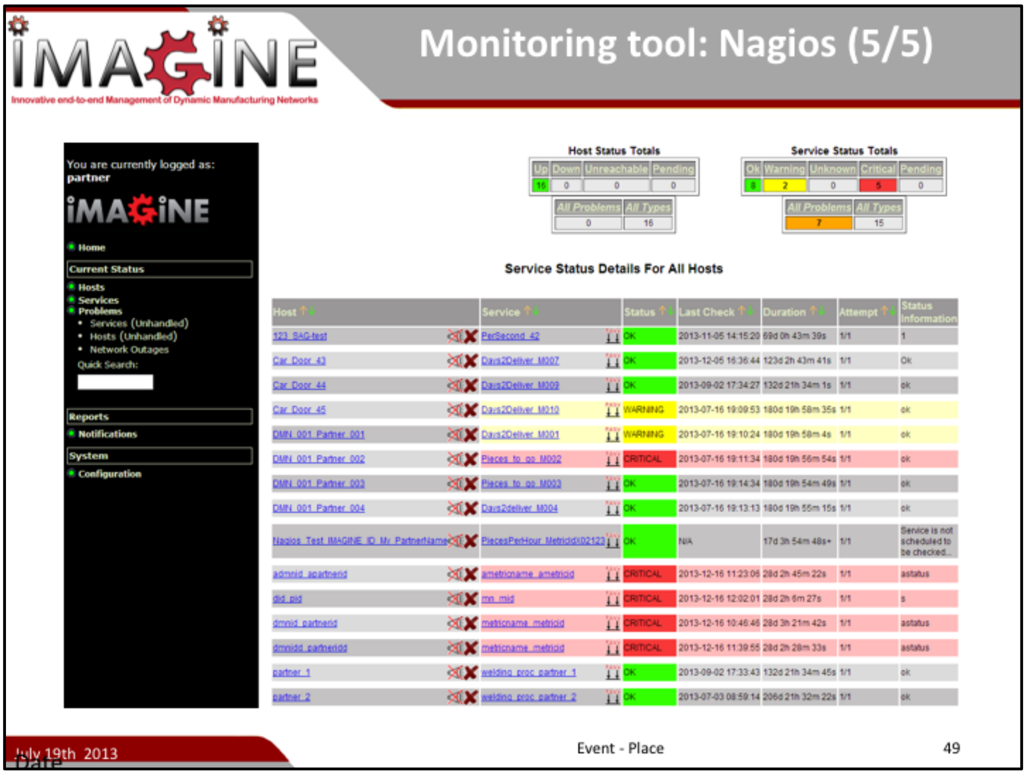

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IMAGINE
Innovative end-to-end Management of Dynamic Manufacturing Networks

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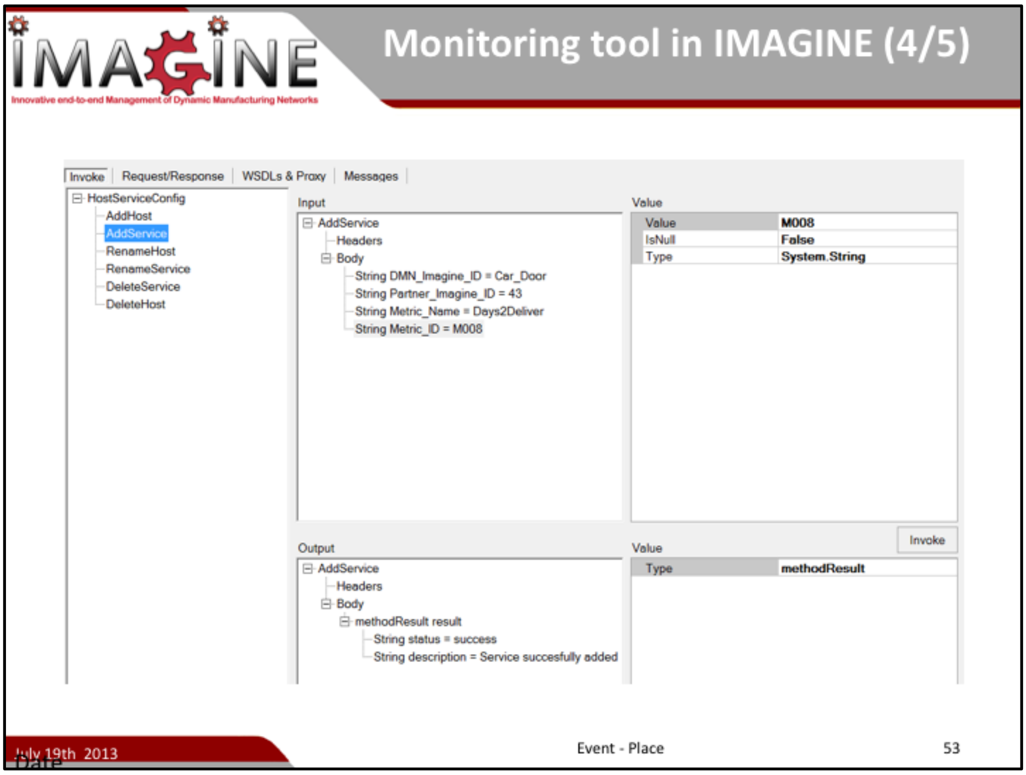

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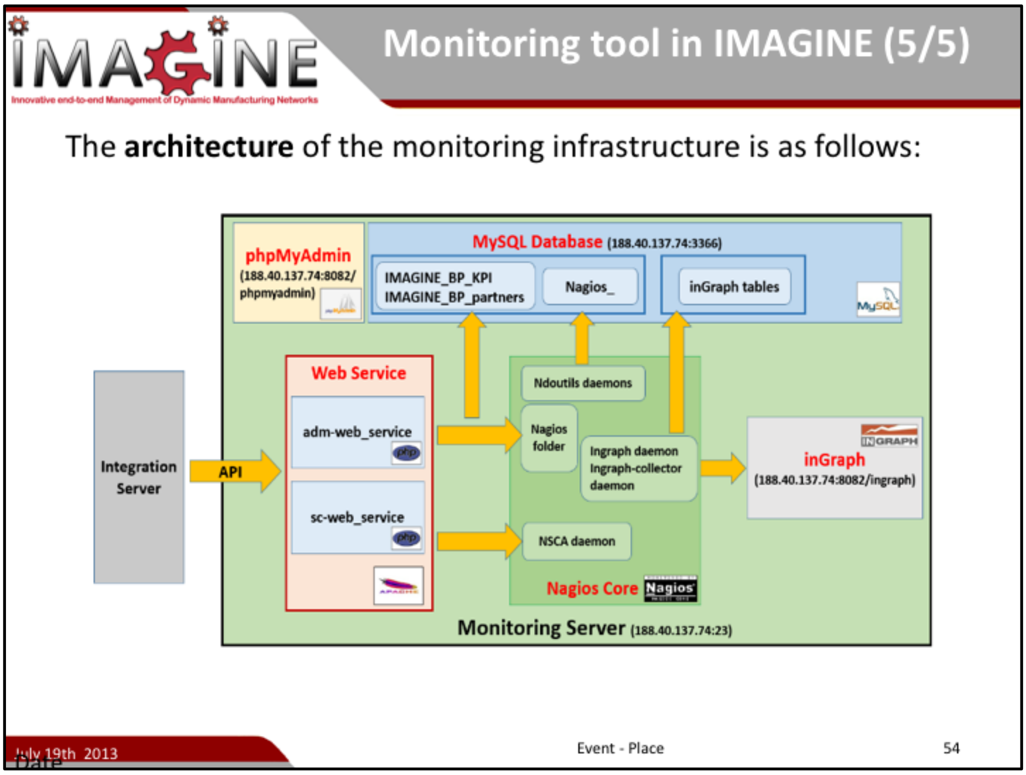

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Thank you for your attention!

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July 19th 2013