13 — Cloud for Industry, Healthcare & Education

This Chapter covers

Applications of cloud computing in:

- Healthcare
- Energy
- Industry
- Education

In this chapter you will learn about applications of cloud computing in healthcare, industry, energy systems and education.

13.1 Cloud Computing for Healthcare

The healthcare ecosystem consists of numerous entities including healthcare providers (primary care physicians, specialists, hospitals, for instance), payers (government, private health insurance companies, employers), pharmaceutical, device and medical service companies, IT solutions and services firms, and patients. The process of provisioning healthcare involves massive healthcare data that exists in different forms (structured or unstructured), can be coded but the skill and accuracy of that coding varies widely, is stored in disparate data sources (such as relational databases, file servers, for instance) and in many different formats. To promote more coordination of care across the multiple providers involved with patients, their clinical information is increasingly aggregated from diverse sources into Electronic Health Record (EHR) systems. Physicians diagnose patients based on information from many sources such as laboratory tests and medical devices (such as CT and MRI scanners,). In the diagnosis process, physicians retrieve and analyze the health information from the EHR. Chronic disease patients are typically seen by multiple physicians at different sites. Care is so distributed that the provider network around the average primary care physician includes some 200 other physicians. Information sharing among them is critical to high quality care. Physicians often seek expert advice from consulting specialists and this process depends on accurate and timely information sharing.

Figure 13.1 shows the application of cloud computing environments to the healthcare ecosystem. The cloud can provide several benefits to all the stakeholders in the healthcare ecosystem through systems such as Health Information Management System (HIMS), Laboratory Information System (LIS), Radiology Information System (RIS), Pharmacy Information System (PIS), for instance. Benefits of cloud computing to various stakeholder in healthcare include:

Providers & Hospitals

With public cloud based EHR systems hospitals don't need to spend a significant portion of their budgets on IT infrastructure. Public cloud service providers provide on-demand provisioning of hardware resources with pay-per-use pricing models. Thus hospitals using public cloud based EHR systems can save on upfront capital investments in hardware and data center infrastructure and pay only for the operating expenses of the cloud resources used. Hospitals can access patient data stored in the cloud and share the data with other hospitals.

Patients

Patients can provide access to their health history and information stored in the cloud (using SaaS applications) to hospitals so that the admissions, care and discharge processes can be streamlined. Physicians can upload diagnosis reports (such as pathology reports) to the cloud so that they can be accessed by doctors remotely for diagnosing the illness. Patients can manage their prescriptions and associated information such as dosage, amount and frequency, and provide this information to their healthcare provider.

Payers

Health payers can increase the effectiveness of their care management programs by providing value added services and giving access to health information to members.

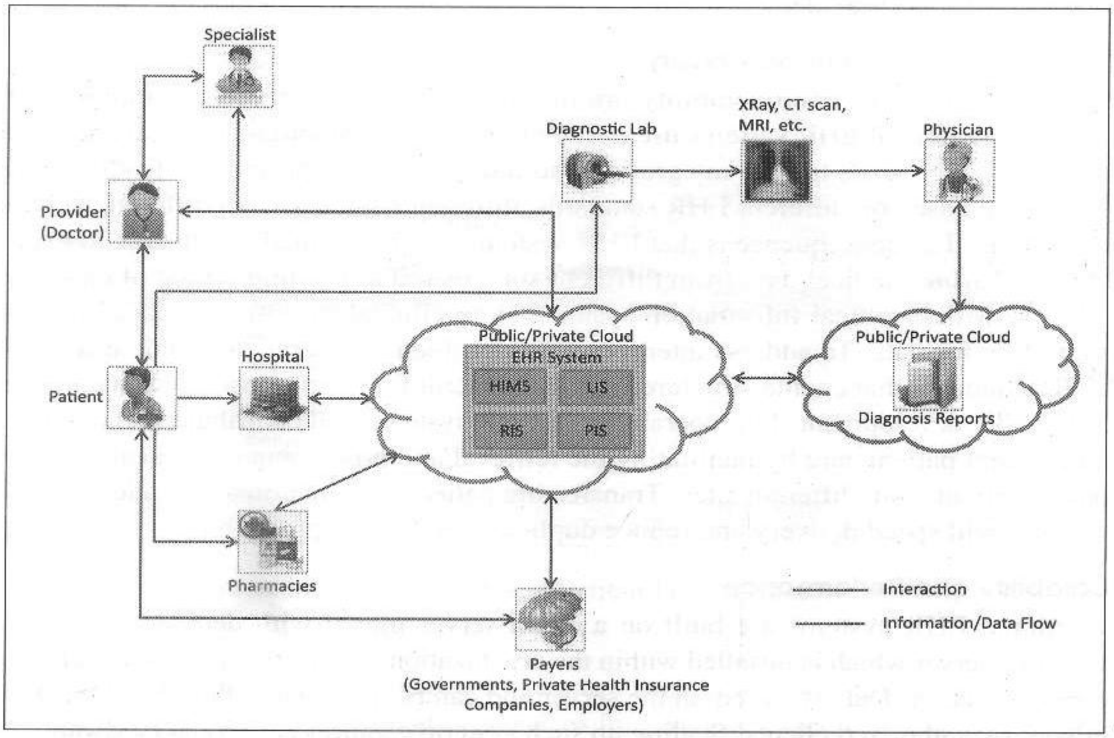

Figure 13.1: Cloud computing for healthcare

EHRs capture and store information on patient health and provider actions including individual-level laboratory results, diagnostic, treatment, and demographic data. Figure 13.2 shows a screenshot of a cloud-based EHR application. The figure shows a patient summary page of a Patient Health Record (PHR) application. The PHR application maintains information such as patient visits, allergies, immunizations, lab reports, prescribed medicines, vital signs, for instance. Though the primary use of EHRs is to maintain all medical data for an individual patient and to provide efficient access to the stored data at the point of care, EHRs can be the source for valuable aggregated information about overall patient populations. The EHR data can be used for advanced healthcare applications such as population-level health surveillance, disease detection, outbreak prediction, public health mapping, similarity-based clinical decision intelligence, medical prognosis, syndromic diagnosis, visual-analytics investigation, for instance. To exploit the potential to aggregate data for advanced healthcare applications there is a need for efficiently integrating information from distributed and heterogeneous healthcare IT systems and analyzing the integrated information. Figure 13.3 shows a screenshot of a HealthMapper application that uses a cloud-based analytics framework to query and analyze patient health records.

High Infrastructure Costs

Traditional client-server EHR systems with dedicated hosting require a team of IT experts to install, configure, test, run, secure and update hardware and software. With cloud-based EHR systems, organizations can save on the upfront capital investments for setting up the computing infrastructure as well as the costs of managing the infrastructure as all of that is done by the cloud provider.

Data Integration & Interoperability

Data integration and interoperability are the major challenges faced by traditional EHR systems. Traditional EHR systems use different and often conflicting technical and semantic standards which leads to data integration and interoperability problems. Traditional EHR systems are based on different EHR standards, different languages and different technology generations. The consequence is that EHR systems are fragmented and unable to exchange data. Acquiring medical data from different sources requires a high grade of data interoperability. Most medical information systems store clinical information about patients in proprietary formats. To address interoperability problems, several electronic health record (EHR) standards that enable structured clinical content for the purpose of exchange are currently under development. Interoperability of EHR systems will contribute to more effective and efficient patient care by facilitating the retrieval and processing of clinical information about a patient from different sites. Transferring patient information automatically between care sites will speed delivery and reduce duplicate testing and prescribing.

Scalability and Performance

Traditional EHR systems are built on a client-server model with dedicated hosting that involves a server which is installed within the organization's network and multiple clients that access the server. Data is stored on the server and can be accessed within the organization's network by authorized clients. Scaling up such systems requires additional hardware. Cloud computing is a hosting abstraction in which the underlying computing infrastructure is provisioned on demand and can be scaled up or down based on the workload. Public cloud-based applications run on cloud infrastructure which is managed by the cloud service provider. Scaling up cloud applications is easier as compared to client-server applications. For cloud-based applications, additional computing resources can be provisioned on-demand when the application workload increases. Cloud offers linear scalability without any changes in the application software.

So far we discussed the benefits of cloud computing for health IT systems. However, security of patient information is one of the biggest obstacles in the widespread adoption of cloud computing technology for EHR systems due to the outsourced nature of cloud computing. Government regulations require privacy protection and security of patient health information. For example, in the U.S., organizations called covered entities (CE), that create, maintain, transmit, use, and disclose an individual's protected health information (PHI) are required to meet Health Insurance Portability and Accountability Act (HIPAA) requirements. HIPAA requires covered entities (CE) to assure their customers that the integrity, confidentiality, and availability of PHI information they collect, maintain, use, or transmit is protected. HIPAA was expanded by the Health Information Technology for Economic and Clinical Health Act (HITECH), which addresses the privacy and security concerns associated with the electronic transmission of health information. Cloud-based

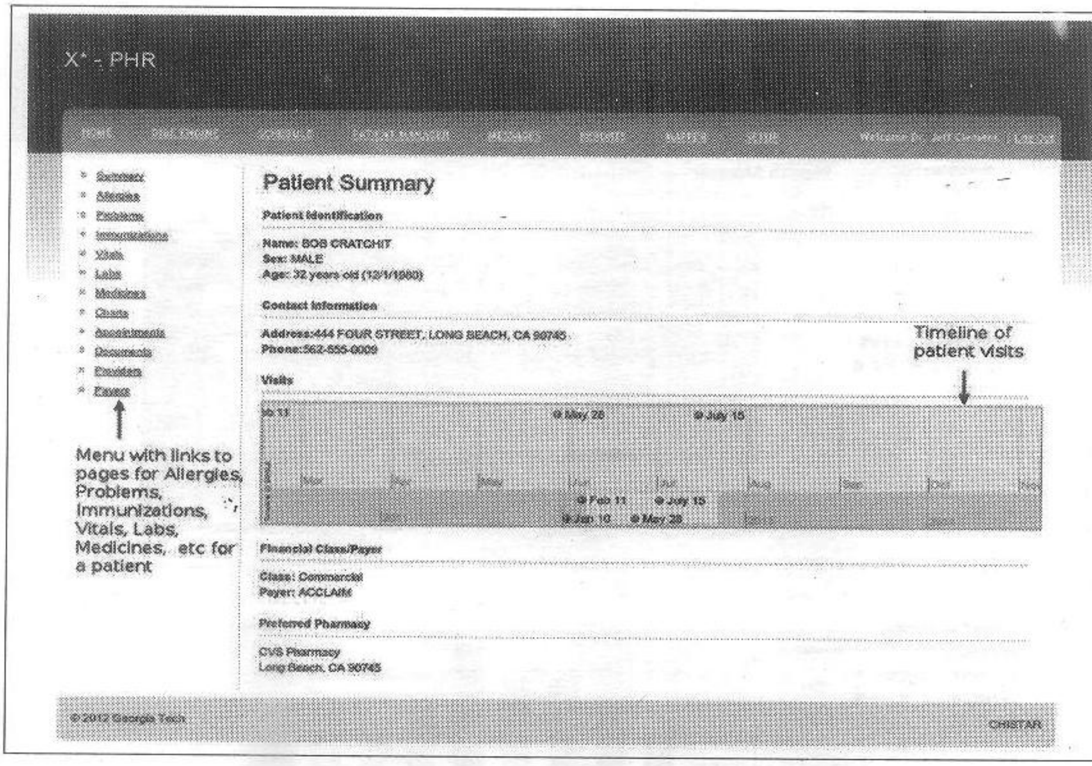

Figure 13.2: Screenshot of a cloud-based Patient Health Record application [10].

health IT systems require enhanced security features such as authorization services, identity management services and authentication services for providing secure access to healthcare data. You learned about these security aspects in Chapter 12.

Figure 13.4 shows the reference architecture for a cloud-based EHR system that can support both primary and secondary use of healthcare data with healthcare data storage and analytics in the cloud. In this architecture, tier-1 consists of web servers and load balancers, tier-2 consists of application servers and tier-3 consists of a cloud based distributed batch processing infrastructure such as Hadoop. HBase is used for the database layer. HBase is a distributed non-relational column oriented database that runs on top of HDFS. HBase provides a fault-tolerant way of storing large quantities of sparse data. HDFS is used for the storage layer for storing healthcare data in the form of flat files, images, for instance. Hive is used to provide a data warehousing infrastructure on top of Hadoop. Hive allows querying and analyzing data in HDFS/HBase using the SQL-like Hive Query Language (HQL). Zookeeper is used to provide a distributed coordination service for maintaining configuration information, naming, providing distributed synchronization, and providing group services.

13.2 Cloud Computing for Energy Systems

Complex clean energy systems (such as smart grids, power plants, wind turbine farms, for instance.) have a large number of critical components that must function correctly so that the

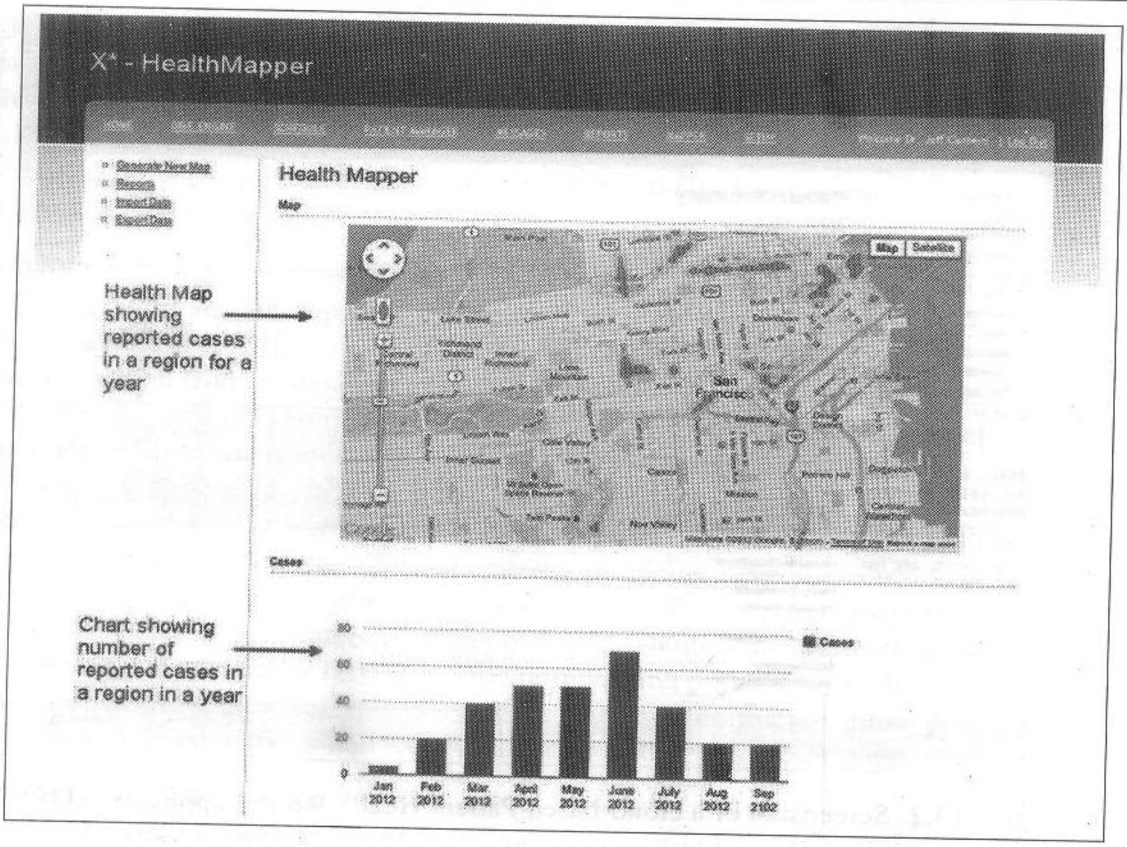

Figure 13.3: Screenshot of a cloud-based HealthMapper application that demonstrates the secondary use of healthcare data.

systems can perform their operations correctly. For example, a wind turbine has a number of critical components, e.g., bearings, turning gears, for instance. that must be monitored carefully as wear and tear in such critical components or sudden change in operating conditions of the machines can result in failures. In systems such as power grids, real-time information is collected using specialized electrical sensors called Phasor Measurement Units (PMU) at the substations. The information received from PMUs must be monitored in real-time for estimating the state of the system and for predicting failures. Energy systems have thousands of sensors that gather real-time maintenance data continuously for condition monitoring and failure prediction purposes. Maintenance and repair of such complex systems is not only expensive but also time consuming, therefore failures can cause huge losses for the operators, and supply outage for consumers.

Prognostic real-time health management involves predicting system performance by analyzing the extent of deviation of a system from its normal operating profiles. Analyzing massive amounts of maintenance data collected from sensors in energy systems and equipment can provide predictions for the impending failures (potentially in real-time) so that their reliability and availability can be improved. Reliability of a system is defined as the probability that a system will perform the intended functions under stated conditions for a specified amount of time. Availability is the probability that a system will perform a specified function

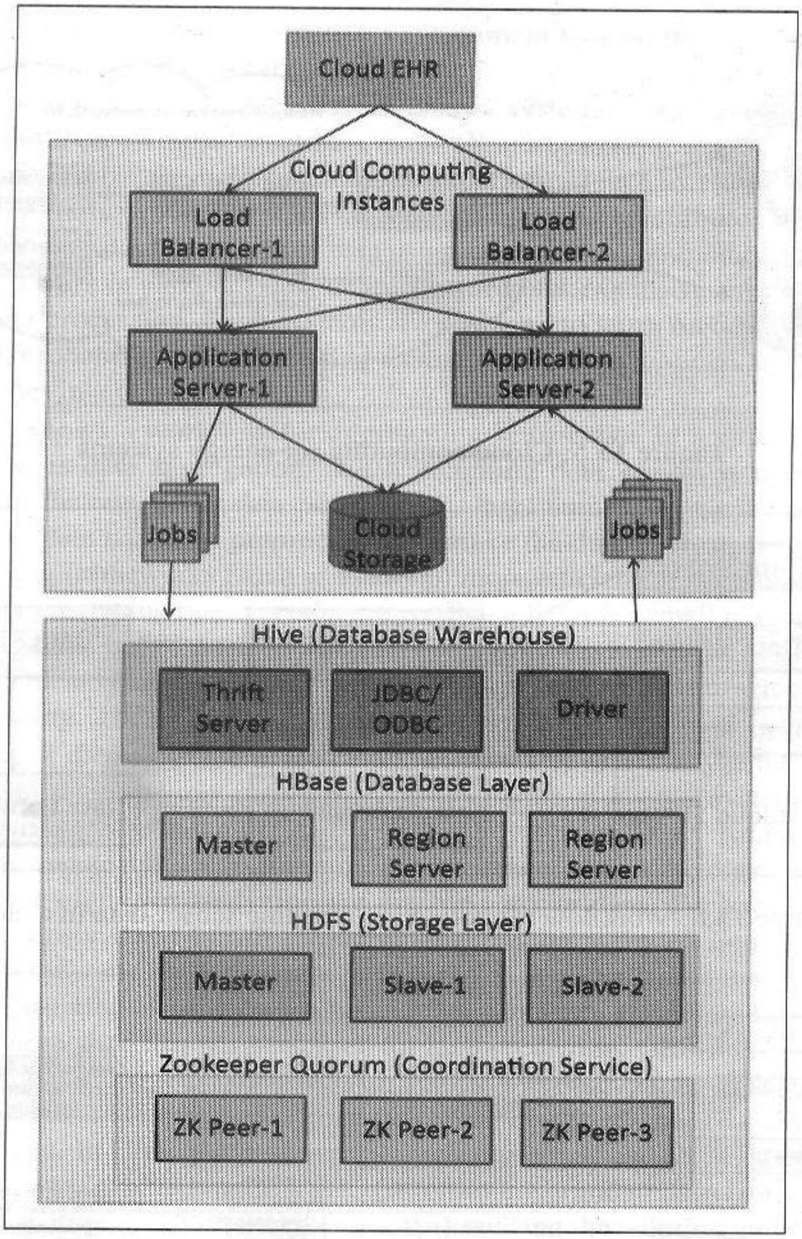

Figure 13.4: Reference architecture for a cloud-based EHR.

under given conditions at a prescribed time. Reliability of a system can be predicted using reliability models and the failure data of the various components of the system. The failure data can be available in the form of manual reports of the repairs of different components or provided in an automated manner by different sensors which monitor the health of the components. The failure data collected from machines is valuable as it can also be used to provide estimates of the reliability and availability that take into consideration the operating conditions and maintenance policies found in real world conditions and practice.

Prognostic health management systems have been developed for different energy systems.

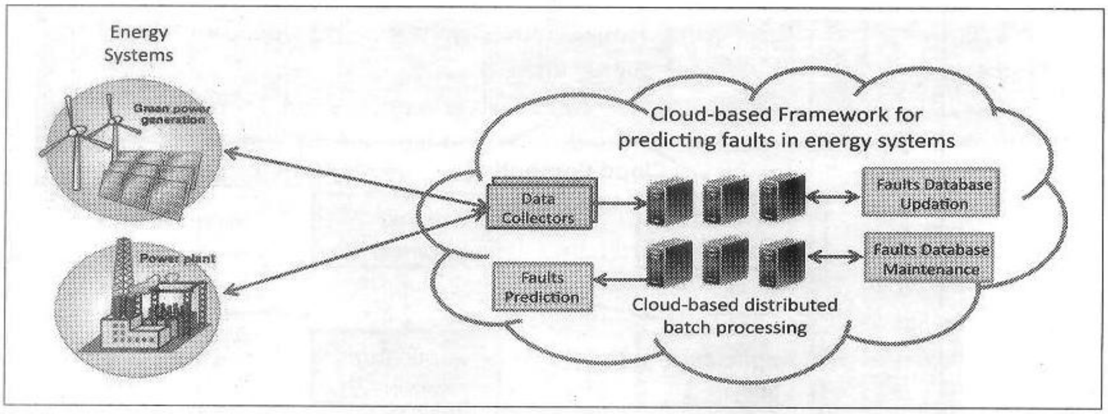

Figure 13.5: Cloud computing for energy systems

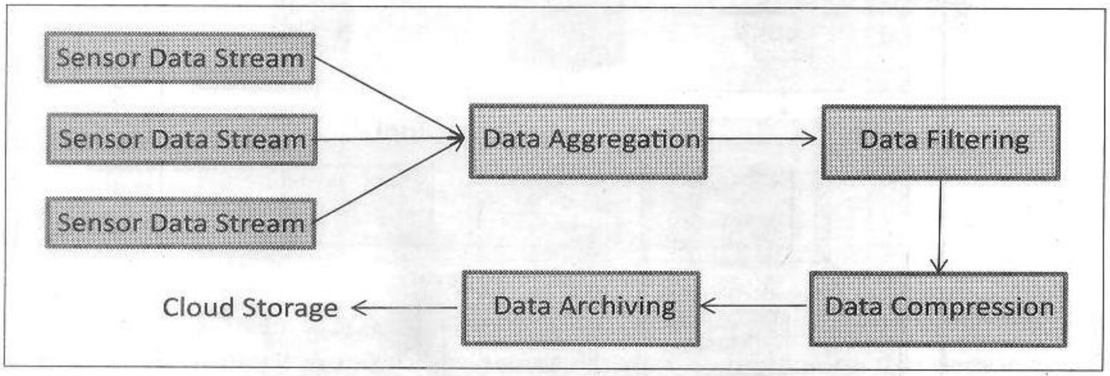

Figure 13.6: Workflow for collecting machine sensor data in a cloud.

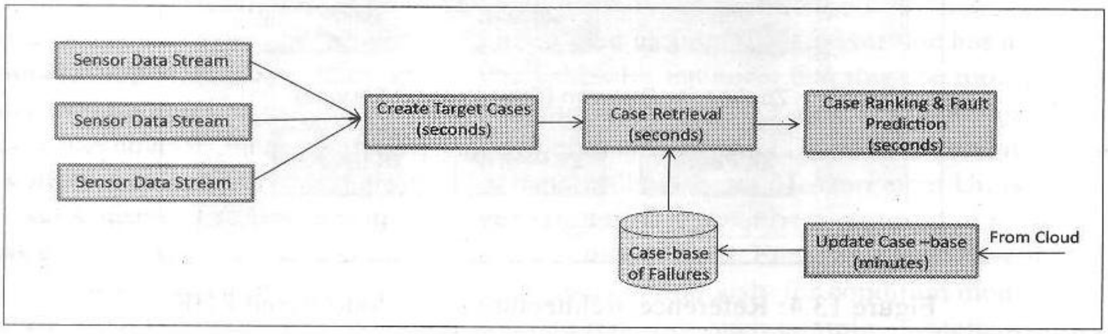

Figure 13.7: Approach for predicting failures in real-time using case-based reasoning demonstrated in [8].

GE has developed a system for gas turbine diagnostics [34]. SKF WindCon [35] is a condition monitoring solution for wind turbines developed by SKF. OpenPDC [36] is a set of applications for processing of streaming time-series data collected from Phasor Measurement Units (PMUs) in real-time. A generic framework for storage, processing and analysis of massive machine maintenance data, collected from a large number of sensors embedded in industrial machines, in a cloud computing environment was proposed in [8]. Figure 13.5 shows a generic use case of cloud for energy systems.

The scale of sensor data collected from energy systems is so large that it is not possible to fit the data on a single machine's disk. Cloud-based big sensor data storage and analytics systems are based on distributed storage systems (such as HDFS) and distributed batch processing frameworks (such as Hadoop). Cloud-based distributed batch processing infrastructures process large volumes of data using inexpensive commodity computers which are connected to work in parallel. Thus there is no need for expensive and reliable hardware for machine data processing. Such systems are designed to work on commodity hardware which has high probability of failure using techniques such as replication of file blocks on multiple machines in a cluster.

Figure 13.6 shows a workflow for aggregating sensor data in a cloud. The first step in this workflow is data aggregation. Each incoming data stream is mapped to a data aggregator. Since the raw sensor data comes from a large number of machines in the form of data streams, the data has to be preprocessed to make the data analysis using cloud-based parallel processing frameworks (such as Hadoop) more efficient. For example, the Hadoop MapReduce data processing model works more efficiently with a small number of large files rather than a large number of small files. The data aggregators buffer the streaming data into larger chunks. The next step is to filter data and remove bad records in which some sensor readings are missing. The filtered data then compressed and archived to a cloud storage.

With the sensor data collected in the cloud, the next step is to analyze the data to predict the state of the system and any impending faults. Faults in energy systems have unique signatures such as increase in temperature, increase in vibration levels, for instance. Various machine learning and analysis algorithms can be implemented over the distributed processing frameworks in the cloud for analyzing the machine sensor data. For example, by cluster analysis of big sensor data, sensor measurements can be assigned into clusters, so that measurements in the same cluster are more similar to each other than to the measurements in other clusters. Clustering algorithms can help in fault isolation. Case-based reasoning (CBR) is another popular method that has been used for fault prediction. CBR finds solutions to new problems based on past experience. CBR is an effective technique for problem solving in the fields in which it is hard to establish a quantitative mathematical model, such as prognostic health management. In CBR, the past experience is organized and represented as cases in a case-base. The steps involved in CBR are: (i) retrieving similar cases from case-base, (ii) reusing the information in the retrieved cases, (iii) revising the solution and (iv) retaining a new experience into the case-base. Figure 13.7 shows an approach based on CBR used for failure prediction in real-time as demonstrated in [8].

Lets us look the application of cloud computing for smart grids. Smart Grid is a data communications network integrated with the electrical grid that collects and analyzes data captured in near-real-time about power transmission, distribution, and consumption. Smart Grid technology provides predictive information and recommendations to utilities, their suppliers, and their customers on how best to manage power.

Figure 13.8 shows how smart grids can use cloud computing. Smart Grids collect data regarding electricity generation (centralized or distributed), consumption (instantaneous or predictive), storage (or conversion of energy into other forms), distribution and equipment health data. Smart grids use high-speed, fully integrated, two-way communication technolo-

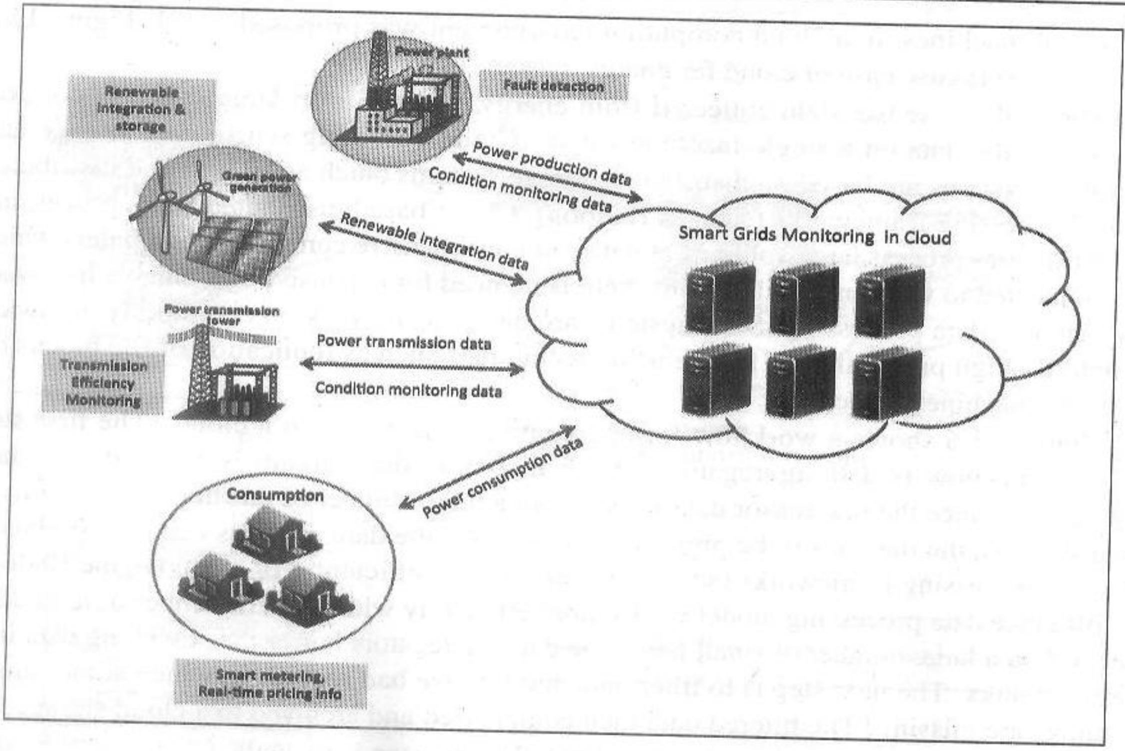

Figure 13.8: Cloud computing for smart grids

gies for real-time information and power exchange. Sensing and measurement technologies are used for evaluating the health of equipment and the integrity of the grid. Power thefts can be prevented using smart metering. By analyzing the data on power generation, transmission and consumption smart girds can improve efficiency throughout the electric system. Storage collection and analysis of smarts grids data in the cloud can help in dynamic optimization of system operations, maintenance, and planning. Cloud-based monitoring of smart grids data can improve energy usage levels via energy feedback to users coupled with real-time pricing information and from users with energy consumption status to reduce energy usage. Real-time demand response and management strategies can be used for lowering peak demand and overall load via appliance control and energy storage mechanisms. Condition monitoring data collected from power generation and transmission systems can help in detecting faults and predicting outages. Probabilistic risk assessments based on real-time measurements can help in identifying the equipment, power plants and transmission lines most likely to fail. Smarts grids data analytics can predict problems before they occur. This allows steps to be taken to minimize impacts and to respond more effectively.

13.3 Cloud Computing for Transportation Systems

Modern transportation systems are driven by data collected from multiple sources which is processed to provide new services to the stakeholders. By collecting large amount of data from various sources and processing the data into useful information, data-driven transportation systems can provide new services such as advanced route guidance [37, 38], dynamic vehicle routing [39], anticipating customer demands for pickup and delivery problem, for instance. Collection and organization of data from multiple sources in real-time and using the massive amounts data for providing intelligent decisions for operations and supply chains, is a major challenge, primarily because the size of the databases involved is very large, and real-time analysis tools have not been available. As a result large organizations are faced with a seemingly unsurmountable problem of analyzing terabytes of unorganized data stored on isolated and distinct geographical locations. However, recent advances in massive scale data processing systems, utilized for driving business operations of corporations provide a promising approach to massive intelligent transportation systems (ITS) data storage and analysis. Figure 13.9 shows a generic use case of cloud for transportation systems.

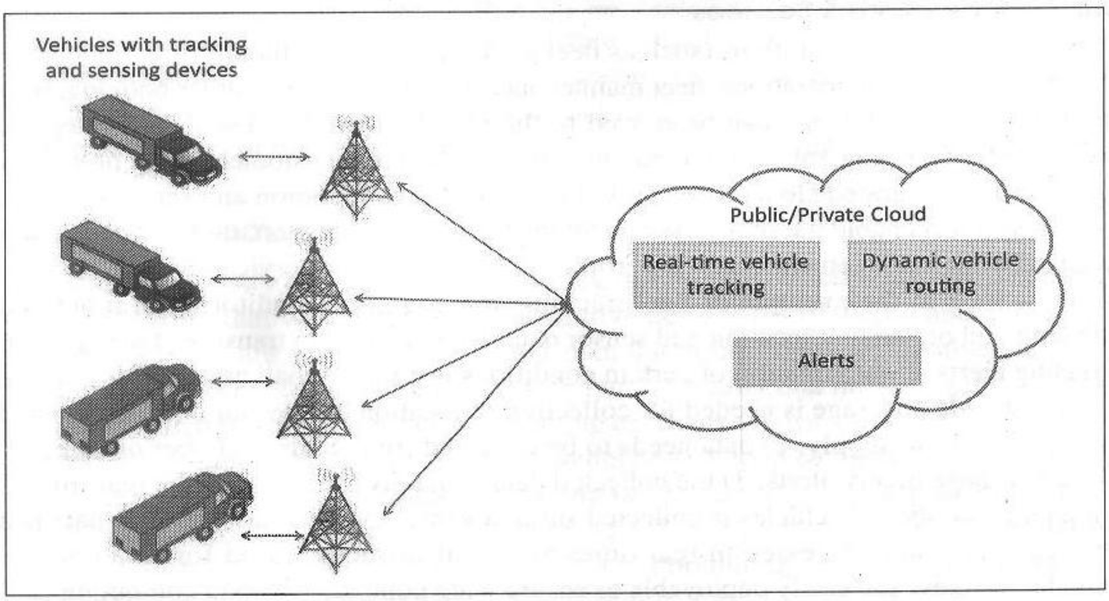

Figure 13.9: Cloud computing for transportation systems

Let us look at some of the applications of cloud computing for transportation systems:

Fleet Tracking

Vehicle fleet tracking systems use GPS technology to track the locations of the vehicles in real-time. Cloud-based fleet tracking systems can be scaled up on demand to handle large number of vehicles. Alerts can be generated in case of deviations in planned routes. Th vehicle locations and routes data can be aggregated and analyzed for detecting bottlen in the supply chain such as traffic congestions on routes, assignments and genera alternative routes, and supply chain optimization.

Route Generation & Scheduling

Route generation and scheduling systems can generate end-to-end routes u of route patterns and transportation modes and feasible schedules based vehicles. As the transportation network grows in size and complexity route combinations increases exponentially. Route administrat difficult to build and keep routes updated in a timely fashion. C and scheduling systems can provide fast response to the route generation queries and can be scaled up to serve a large transportation network.

Condition Monitoring

Condition monitoring solutions for transportation systems allow monitoring the conditions inside containers. For example, containers carrying fresh food produce can be monitored to prevent spoilage of food. Condition monitoring with sensors such as temperature, pressure, humidity, for instance. for a large fleet of vehicles can generate big data that can be difficult to analyze in real time. Cloud-based systems can be used for this purpose that not only detect food spoilage but also suggest alternative routes to prevent spoilage.

Planning, Operations & Services

Different transportation solutions (such as fleet tracking, condition monitoring, route generation, scheduling, cargo operations, fleet maintenance, customer service, order booking, billing & collection, for instance.) can be moved to the cloud to provide a seamless integration between order management, tactical planning & execution and customer facing processes & systems. Such integrated cloud-based systems for planning, operation and services for transportation systems enable the organizations to improve asset utilization, increase contribution, reduce network management costs (e.g. roll costs), and improve service levels.

Let us look at the example of fleet tracking and condition monitoring in more detail. Collecting and organizing location and sensor data from vehicles in transit and using the data for raising alerts about violation of certain conditions is a major challenge for the following reasons: 1) wide coverage is needed for collection of location and sensor data from vehicles carrying fresh food supply; 2) data needs to be collected from a large number of vehicles in real-time to raise timely alerts; 3) the collected data is massive scale, since the real-time data from a large number of vehicles is collected simultaneously; 4) the massive scale data needs to be organized and processed in real-time; 5) the infrastructure used for data collection should be low cost and easily deployable to ensure wide popularity. Cloud computing can be leveraged for such applications.

A cloud-based framework for real-time fresh food supply tracking and monitoring was proposed in [9]. Fresh food can be damaged during transit due to unrefrigerated conditions and changes in environmental conditions such as temperature and humidity, which can lead to microbial infections and biochemical reactions or mechanical damage due to rough handling. Spoilage of fruits and vegetables during transport and distribution not only results in losses to the distributors but also presents a hazard to the food safety. Therefore tracking and monitoring of fresh food supply is an important problem that needs to be addressed. Since fresh foods have short durability, tracking the supply of fresh foods and monitoring the transit conditions can help identification of potential food safety hazards. The analysis and interpretation of data on the environmental conditions in the container and food truck positioning can enable more effective routing decisions in real time. Therefore, it is possible to take remedial measures such as, (1) the food that has a limited time budget before it gets rotten can be re-routed to a closer destinations, (2) alerts can be raised to the driver and the distributor about the transit conditions, such as container temperature exceeding the allowed limit, humidity levels going out of the allowed limit, for instance., and corrective actions can be taken before the food gets damaged.

Monitoring and tracking supply chain transportation fleet involves a large amount of data. The scale of the location and sensor data involved for a fleet of vehicles is very large. For example, if the location and sensor readings are collected from 1000 vehicles every one minute then 1.44 million records will be created in one day on the server. Scalability is required both in terms of data storage and analysis. The advantage of using a cloud computing environment for data storage and analysis is that it is possible to organize and analyze real-time data from a large number of vehicles. Scalable algorithms for data analysis (such as generation of alerts and optimal routes) can be developed by leveraging the parallel computing capability of a computing cloud based on a large-scale distributed batch processing infrastructure. A cloud computing based approach also provides flexibility in data analysis jobs as the frequency of analysis jobs can be varied. Cloud computing resources can be provisioned on a just-in-time basis based on the demand. For example, if the number of vehicles registered with the tracking and monitoring service become large additional computing resources can be provisioned on-demand. The frequency of location and sensor data collection and data analysis in the cloud can also be increased or decreased depending on the requirements of the vehicles and type of food produce being transported.

13.4 Cloud Computing for Manufacturing Industry

Manufacturing industry researchers are exploring the potential of utilizing cloud computing for manufacturing that would enable collaborative design, distributed manufacturing and co-creation. There are two forms of cloud manufacturing, one that involves the use of cloud computing technologies for manufacturing and the other that involves service-oriented manufacturing that replicates the cloud computing environment using physical manufacturing resources (like computing resources in cloud computing). Cloud computing is well suited for manufacturing industry in which the computing needs vary significantly with the product lifecycle phase. Cloud computing can help in manufacturing by providing computational, storage and software services on demand. Cloud computing allows improved resource sharing, rapid prototyping, and reduces cost of manufacturing.

An application of cloud computing technologies for manufacturing is the Industrial Control Systems (ICS) data analytics. Industrial control systems such as supervisory control and data acquisition (SCADA) systems, distributed control systems (DCS), and other control system configurations such as Programmable Logic Controllers (PLC) found in the manufacturing industry continuously generate monitoring and control data. Real-time collection, management and analysis of data on production operations generated by ICS, in the cloud, can help in estimating the state of the systems, improve plant and personnel safety and thus take appropriate action in real-time to prevent catastrophic failures. Wu et. al. [40] have proposed to expand the paradigm of cloud computing to the field of computer-aided design and manufacturing and propose a new concept of cloud-based design and manufacturing (CBDM).

Figure 13.10 shows an example of services in cloud-based design and manufacturing including:

Software-as-a-Service (SaaS)

SaaS service model provides software applications such as customer relationship management (CRM), enterprise relationship management (ERP), computer aided design and manufacturing (CAD/CAM) hosted in a computing cloud, through thin clients such as web browsers. SaaS

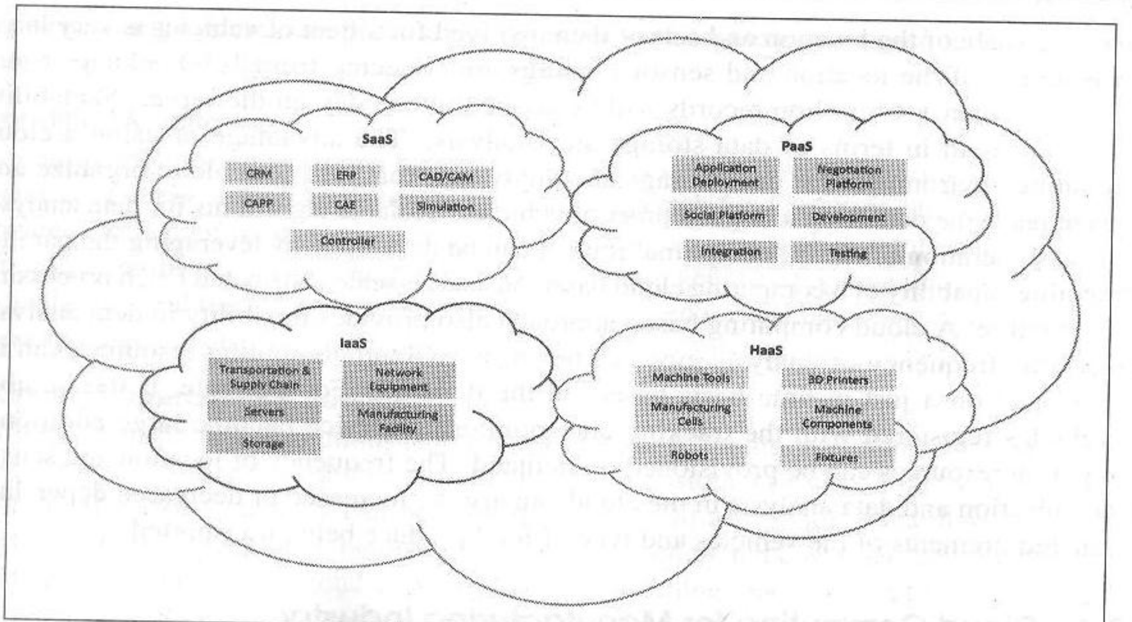

Figure 13.10: Cloud-based design and manufacturing

applications can be accessed by multiple teams spread across different locations working in a collaborative development environment.

Platform-as-a-Service (PaaS)

PaaS service model allows deployment of applications without the need for buying or managing the underlying infrastructure. PaaS provides services for developing, integrating and testing applications in an integrated development environment. Design teams can leverage PaaS for collaboration and enhance their productivity.

Infrastructure-as-a-Service (IaaS)

IaaS provides physical resources such as servers, storage that can be provisioned on demand.

Hardware-as-a-Service (HaaS)

HaaS provides access to machine tools, 3D printers, manufacturing cells, industrial robots, for instance. HaaS providers can rent hardware to consumers through the CBDM environment. For example, a HaaS service for 3D printing can be used by multiple organizations for printing 3D parts. Cloud connected 3D printers allow rapid tooling which makes rapid scalability possible for traditional manufacturing processes requiring tools.

13.5 Cloud Computing for Education

Cloud computing is bringing a transformative impact in the field of education by improving the reach of quality education to students through the use of online learning platforms and collaboration tools.

In the recent years the concept of Massively Online Open Courses (MOOCs) appears to be gaining popularity worldwide with large numbers students enrolling for online courses.

MOOCs are aimed for large audiences and use cloud technologies for providing audio/video content, readings, assignment and exams. Cloud-based auto-grading applications are used for grading exams and assignments. Cloud-based applications for peer grading of exams and assignments are also used in some MOOCs. MOOCs encourage discussions between students through online discussion boards. Cloud technologies make large-scale feedback and interactions possible by provisioning resources on demand and providing seamless scalability. Cloud computing thus has the potential of helping in bringing down the cost of education by increasing the student-teacher ratio through the use of online learning platforms and new evaluation approaches without sacrificing quality.

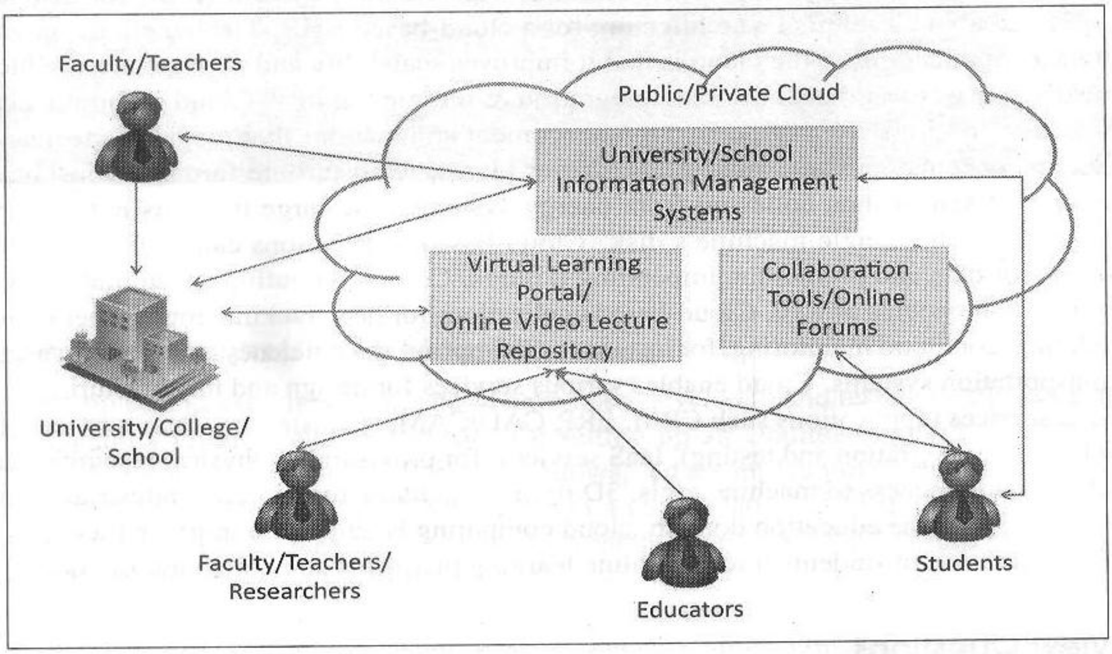

Figure 13.11: Cloud computing for education

Many universities across the world are using cloud platforms for providing online degree programs. Lectures are delivered through live/recorded video using cloud based content delivery networks to students across the world. Online proctoring for distance learning programs is also becoming popular through the use of cloud-based live video streaming technologies where online proctors observe test takers remotely through video. Access to virtual labs is provided to distance learning students through the cloud. Virtual labs provide remote access to the same software and applications that are used by students on campus. Cloud-based course management platforms are used to for sharing reading materials, providing assignments and releasing grades, for instance.

Cloud-based collaboration applications such as online forums, can help student discuss common problems and seek guidance from experts. Universities, colleges and schools can use cloud-based information management systems to improve administrative efficiency, offer online and distance education programs, online exams, track progress of students, collect feedback from students, for instance. Figure 13.11 shows a generic use case of cloud for education. Cloud-based systems can help universities, colleges and schools in cutting down the IT infrastructure costs and yet provide access to educational services to a large number of students.

Summary

In this chapter you learned about the applications of cloud computing in healthcare, industry, energy systems and education. The cloud can provide several benefits to all the stakeholders in the healthcare ecosystem (Providers & Hospitals, Patients and Payers) through systems such as Health Information Management System (HIMS), Laboratory Information System (LIS), Radiology Information System (RIS), Pharmacy Information System (PIS), for instance. You learned about a reference architecture for a cloud-based EHR. The benefit of moving healthcare applications to the cloud is that it improves scalability and performance, reduces infrastructure costs and enables data integration & interoperability. Cloud computing can be used for prognostic real-time health management applications that predict performance of energy systems (such as smart grids, power plants, wind turbine farms, for instance.) The scale of sensor data collected from energy systems is so large that it is not possible to fit the data on a single machine's disk. Cloud-based applications can analyze massive scale sensor data and predict the impending failures. Cloud computing has applications in transportation systems as well. Cloud-based applications for fleet tracking, route generation & scheduling, condition monitoring, for instance. can improve the efficiency and reduce wastage in transportation systems. Cloud enables various services for design and manufacturing such as Saas services (applications such CRM, ERP, CAD/CAM, for instance.), PaaS services (for development, integration and testing), IaaS services (for provisioning physical resources) and HaaS (provides access to machine tools, 3D printers, manufacturing cells, industrial robots, for instance.). In the education domain, cloud computing is helping to improve the reach of quality education to students through online learning platforms and collaboration tools.

Review Questions

1. What are the benefits of using cloud for EHR systems?
2. What aspects of cloud computing make it useful for prognostic health management applications for energy systems?
3. What are the steps involved in case-based reasoning?
4. What is cloud-based design and manufacturing?