in many environments is one of the reasons why these environments take the shape of ecosystems.

Some of the main challenges associated with the implementation of cyber-physical systems in include affordability, network integration, and the interoperability of engineering systems.

Most companies have a difficult time justifying risky, expensive, and uncertain investments for smart manufacturing across the company and factory level. Changes to the structure, organization, and culture of manufacturing occur slowly, which hinders technology integration. Pre-digital age control systems are infrequently replaced because they are still serviceable. Retrofitting these existing plants with cyber-physical systems is difficult and expensive. The lack of a standard industry approach to production management results in customized software or use of a manual approach. There is also a need for a unifying theory of non-homogeneous control and communication systems [82].

3.3.6 Smart Health

The market for health monitoring devices is currently characterised by application-specific solutions that are mutually non-interoperable and are made up of diverse architectures. While individual products are designed to cost targets, the long-term goal of achieving lower technology costs across current and future sectors will inevitably be very challenging unless a more coherent approach is used. The IoT can be used in clinical care where hospitalized patients whose physiological status requires close attention can be constantly monitored using IoT -driven, noninvasive monitoring. This requires sensors to collect comprehensive physiological information and uses gateways and the cloud to analyze and store the information and then send the analyzed data wirelessly to caregivers for further analysis and review. These techniques improve the quality of care through constant attention and lower the cost of care by eliminating the need for a caregiver to actively engage in data collection and analysis. In addition the technology can be used for remote monitoring using small, wireless solutions connected through the IoT. These solutions can be used to securely capture patient health data from a variety of sensors, apply complex algorithms to analyze the data and then share it through wireless connectivity with medical professionals who can make appropriate health recommendations.

The links between the many applications in health monitoring are:

- gathering of data from sensors
- support user interfaces and displays

- network connectivity for access to infrastructural services
- low power, robustness, durability, accuracy and reliability.

IoT applications are pushing the development of platforms for implementing ambient assisted living (AAL) systems that will offer services in the areas of assistance to carry out daily activities, health and activity monitoring, enhancing safety and security, getting access to medical and emergency systems, and facilitating rapid health support.

The main objective is to enhance life quality for people who need permanent support or monitoring, to decrease barriers for monitoring important health parameters, to avoid unnecessary healthcare costs and efforts, and to provide the right medical support at the right time.

The IoT plays an important role in healthcare applications, from managing chronic diseases at one end of the spectrum to preventing disease at the other.

Challenges exist in the overall cyber-physical infrastructure (e.g., hardware, connectivity, software development and communications), specialized processes at the intersection of control and sensing, sensor fusion and decision making, security, and the compositionality of cyber-physical systems. Proprietary medical devices in general were not designed for interoperation with other medical devices or computational systems, necessitating advancements in networking and distributed communication within cyber-physical architectures. Interoperability and closed loop systems appears to be the key for success. System security will be critical as communication of individual

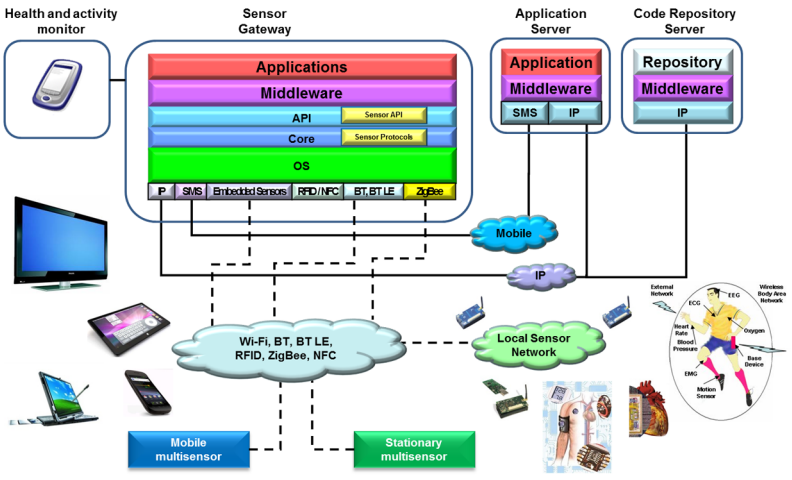

Figure 3.36 Smart Health Platform

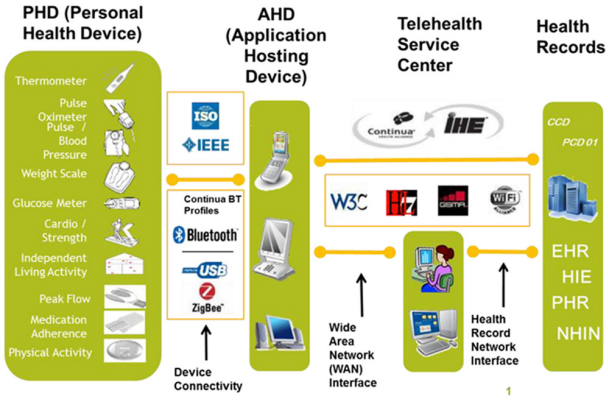

Figure 3.37 Interoperable standard interfaces in the Continua Personal Health Eco-System (Source: Continua Health Alliance)

patient data is communicated over cyber-physical networks. In addition, validating data acquired from patients using new cyber-physical technologies against existing gold standard data acquisition methods will be a challenge. Cyber-physical technologies will also need to be designed to operate with minimal patient training or cooperation [83].

New and innovative technologies are needed to cope with the trends on wired, wireless, high-speed interfaces, miniaturization and modular design approaches for products having multiple technologies integrated.

Internet of Things applications have a future market potential for electronic health services and connected telecommunication industry. In this context, the telecommunications can foster the evolution of ecosystems in different application areas. Medical expenditures are in the range of 10% of the European gross domestic product. The market segment of telemedicine, one of lead markets of the future will have growth rates of more than 19%.

The Continua Health Alliance, an industry consortium promoting telehealth and guaranteeing end-to-end interoperability from sensors to health record databases, has defined in its design guidelines, a dual interface for communication with physiological and residential sensors showing a Personal Area Network (PAN) interface based on Bluetooth Low Energy (BLE) standard and its health device profiles, and a Local Area Network (LAN) interface, based on the Zigbee Health Care application profile. The standards are relatively similar in terms of complexity but BLE, tends to have a longer battery life primarily due to the use of short packet overhead and faster data rates, reduced number of packet exchanges for a short discovery/connect time, and skipped

communication events, while Zigbee benefits from a longer range and better reliability with the use of a robust modulation scheme (Direct Sequence Spread Spectrum with orthogonal coding and a mesh-like clustered star networking technology)

Convergence of bio parameter sensing, communication technologies and engineering is turning health care into a new type of information industry. In this context the progress beyond state of the art for IoT applications for healthcare is envisaged as follows:

- Standardisation of interface from sensors and MEMS for an open platform to create a broad and open market for bio-chemical innovators.
- Providing a high degree of automation in the taking and processing of information;
- Real-time data over networks (streaming and regular single measurements) to be available to clinicians anywhere on the web with appropriate software and privileges;
- Data travelling over trusted web.
- Reuse of components over smooth progression between low-cost "home health" devices and higher cost "professional" devices.
- Data needs to be interchangeable between all authorised devices in use within the clinical care pathway, from home, ambulance, clinic, GP, hospital, without manual transfer of data.

3.3.7 Food and Water Tracking and Security

Food and fresh water are the most important natural resources in the world. Organic food produced without addition of certain chemical substances and according to strict rules, or food produced in certain geographical areas will be particularly valued. Similarly, fresh water from mountain springs is already highly valued. In the future it will be very important to bottle and distribute water adequately. This will inevitably lead to attempts to forge the origin or the production process. Using IoT in such scenarios to secure tracking of food or water from the production place to the consumer is one of the important topics.

This has already been introduced to some extent in regard to beef meat. After the "mad cow disease" outbreak in the late 20th century, some beef manufacturers together with large supermarket chains in Ireland are offering "from pasture to plate" traceability of each package of beef meat in an attempt to assure consumers that the meat is safe for consumption. However, this is