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MOVET

Modernisation of VET through
Collaboration with the Industry

Radoslav Vargic
Peter Trúchly
Pavol Podhradský

Smart technologies

Erasmus+

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Title: Smart technologies

Author: Radoslav Vargic,
Peter Trúchly,
Pavol Podhradský

Published by: Czech Technical University of Prague
Faculty of electrical engineering

Contact address: Technicka 2, Prague 6, Czech Republic

Phone Number: +420 224352084

Print: (only electronic form)

Number of pages: 42

Edition: 1st Edition, 2019

MoVET
Modernisation of VET through
Collaboration with the Industry

https://movet.fel.cvut.cz

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Explanatory Notes

	Definition
	Interesting
	Note
	Example
	Summary
	Advantage
	Disadvantage

ANNOTATION

The rise of smart technologies and intelligent automation is changing the world. They allow us to simplify and improve life at homes, in a cities and communities. They are capable to adapt automatically and modify their behaviour to fit environment requirements and conditions. Smart technologies use sensors to sense things, acquire data and analyse them and draw conclusions based on rules. They are also capable to learn. This module provides an introduction to smart technologies. It describes and explains what smart technologies are what are their main features, advantages, disadvantages and uses or applications.

OBJECTIVES

The main goal of this module is to introduce a student to a domain of smart technologies. Students get to know basic characteristics of smart homes and components they contain. Students also acquaint with basic features and structure of smart home devices such as smart TVs or smart kitchen appliances as well as smart end user devices such as smartphones, smart glasses and watches. They learn about smart cities and components making cities and communities to be smart. And they also acquire basic information from a short overview of smart machines in enterprises.

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1 Smart homes

A smart home is a residence that uses internet-connected devices for remote monitoring and management of various appliances and systems (e.g. heating, lighting).

Smart home technology is often called home automation or domotics. The main areas for home automation are security, comfort and energy efficiency. Owner can control it usually using his smartphone or other networked device. The first general purpose home automation network protocol was X10, which uses power lines for control signal transmission. These signals convey commands to corresponding devices, controlling how and when they should operate (e.g. turn on at a specific time). Today's home automation network protocols ale mostly covered by the *Internet of things* (**IoT**) protocols as Zigbee, Z-Wave, LoRaWan, SigFox, NB-IoT, etc. as well as WiFi and Bluetooth. Many companies including Amazon, Apple and Google have released their own smart home products and home automation platforms as Amazon Echo, Apple HomeKit and Google Home. Newly built homes are often constructed with smart home infrastructure in place. Older homes, on the other hand, can be retrofitted with smart technologies.

Fig. 1 Smart home and illustration of some of its representative technologies

Smart home technologies have widely entered the domestic space touching nearly every aspect of life. Some representative technologies among them are:

- Smart TV - they connect to the Internet to access content through applications, such as on-demand video and music. Some smart TVs also include voice or gesture recognition.

- Smart Lighting systems - the devices are not one able to be controlled remotely and customized, they can e.g. detect when occupants are in the room and adjust lighting as needed, regulate themselves based on daylight availability, etc.
- Smart Thermostats - allow e.g. to schedule, monitor and remotely control home temperatures. Thy can also learn homeowners' behaviors and automatically and adapt to provide residents more comfort.
- Smart Locks and garage-door openers can e.g. detect when residents are near and unlock.
- Smart security cameras can e.g. monitor the homes when the owners are away or on vacation.
- Smart motion sensors can identify the difference between residents, visitors, pets and burglars, and can notify authorities if suspicious behavior is detected.
- Smart coffee makers can brew a fresh cup e.g. at scheduled time
- Smart refrigerators can keep track of expiration dates and make shopping lists
- Smart electricity plug - can e.g. sense an electric surge and turn off
- Smart water maters can detect failures or freezing pipes and turn off the water to avoid a flood.

Smart home can offer many benefits, among them are following:

- Peace of mind - remote monitoring feature allows users to monitor their homes, countering dangers such as a forgotten coffee maker left on or a front door left unlocked.
- Elderly - remote monitoring can help seniors to remain at home comfortably and safely, rather than moving to a nursing home or requiring 24/7 home care.
- Comfort and user preferences - smart homes can accommodate user preferences. E.g. as soon as you arrive home, your garage door will open, the lights will go on, the fireplace will roar and your favorite tunes will start playing on your smart speakers.
- Efficiency - smart home automation helps to improve efficiency, for electricity, water and other resources, e.g. by using.
- Smart heating / cooling - automation can learn to perform the necessary heating / cooling just in time e.g. house is cooled down by the time the owner arrives home from work.
- Smart irrigation system - the lawn will only be watered when needed and with the exact amount of water necessary.

However, smart home systems have struggled to become mainstream, in part due to their drawbacks, which are e.g. as follows:

- Perceived complexity. Some people have difficulty with technology or will give up on it with the first annoyance. Smart home manufacturers and alliances are working on reducing complexity and improving the user experience to make it enjoyable and beneficial for users of all types and technical levels.
- Interoperability. For home automation systems to be truly effective, devices must be interoperable regardless of who manufactured them, using the same protocol or, at least, complementary ones. As it is such a nascent market, there is no gold standard for home automation yet. However, standard alliances are partnering with manufacturers and protocols to ensure interoperability and a seamless user experience.
- Smart home security. If hackers are able to infiltrate a smart device, they could potentially turn off the lights and alarms and unlock the doors, leaving a home defenseless to a break-in. Further, hackers could potentially access the homeowner's network, leading to worse attacks or data exfiltration.
- Data privacy. It is about the privacy of the data shared by their smart home devices. While smart home device and platform manufacturers may collect consumer data to better tailor their products or offer new and improved services to customers, trust and transparency are critical to manufacturers building trust with the users of their smart products.

A smart home is not set of disparate smart devices and appliances, but ones that work together to create a remotely controllable network. All devices are controlled by a master home automation controller, often called a smart home hub.

The smart home hub is a hardware device that acts as the central point of the smart home system and is able to sense, process data and communicate wirelessly. It combines all of the disparate apps into a single smart home app that can be controlled remotely by homeowners. The most known hubs usually have voice-activated systems, contain virtual assistants that learn and personalize the smart home to the residents' preferences and patterns. They contain machine learning algorithms allowing home automation applications to adapt to their environments. Examples of smart home hubs include:

- Amazon Echo. Speech interface provides Alexa.
- Google Home. It serves too as the music and entertainment hub that manages other speakers and TVs via Google Cast. Speech interface provides Google Assistant. It is capable to control the compatible devices.
- HomePod. Speech interface provides Siri. It can control the Apple HomeKit platform. It is capable to control the HomeKit compatible devices. The AppleTV can also be used as local HomeKit.

Fig. 2 Examples of Smart home hubs (from left to right - Google Home, HomePod, Amazon Echo)

For reasonable automation the central unit (hub) needs the set of sensors to control the actuators. The scenarios can be complex and condition, where the particular action is performed can be combined from multiple sensors and conditions. The sensors include:

- outer conditions monitoring (temperature, pressure, humidity, ...),
- inner conditions (temperature, pressure, CO_2, ...),
- flood detection,
- movement detection,
- door/window open/close detection,
- resources consumption (heating, water, electricity, gas, ...).

As the actuators there are also many options, among others:

- electricity switches (on/off),
- window open/close control,
- water valve control,
- blinds control,
- heating/cooling/air conditioning/air humidifier/etc.,
- lighting (external, internal, ...),
- alarms, notifications, ...,
- alarm,

- notifications,
- air filtration, humidity, etc.

Some smart home systems can be created from scratch, for example, using a Raspberry Pi or other prototyping board. Others can be purchased as a bundled smart home kit - also known as a smart home platform - that contains the pieces needed to start a home automation project. There are also many open source software systems for smart home automation as [1], [2], [3]:

- *OpenHAB* (**OH**) [4] - It has large user community, huge number of supported devices and integrations. It is written in Java, runs also on the Raspberry Pi and is designed to be device-agnostic. OH includes iOS and Android apps for device control, as well as design tools. It is licensed under Eclipse Public License.
- *Home assistant* (**HA**) [5] - It is easily deployable on any machine that can run Python 3 and it integrates with a large number of open source as well as commercial offerings. It is licensed under MIT license and supports
    - integration with amazon Alexa,
    - integration with Google Assistant.
- Calaos - Calaos is designed as a full-stack home automation platform, including a server application, touchscreen interface, web application, native mobile applications for iOS and Android, and a preconfigured Linux operating system to run underneath. It is licensed under GPLv3.
- Domoticz - It has a wide library of supported devices, large number of additional third-party integrations, it is designed with an HTML5 frontend and represents a lightweight home automation system (e.g. can run on Raspberry Pi). It is licensed under GPLv3
- MisterHouse - It uses Perl scripts, responds to voice commands, and runs on variety of devices including Linux, macOS, and Windows. It is licensed under GPLv2.
- OpenMotics - It includes hardware and software under open source licenses. It is primarily designed for easy retrofitting, focuses on a hardwired solution. It is licensed under GPLv2.

It seems that the most used solutions are AH and OH [6]. When comparing them, the OH seems to be a great choice for the experienced users (especially coders) as the complicated built-in tools give you superpowers to customize and tinker with the routines. All other users, however, should go for HA as a more consumer friendly product creating a comprehensive smart home eco-system.

While every **smart home is a smart building**, **not every smart building is a smart home**. Enterprise, commercial, industrial and residential buildings of all shapes and sizes - including offices, skyscrapers, apartment buildings, and multi-tenant offices and residences - are deploying IoT technologies to improve building efficiency, reduce energy costs and environmental impact, and ensure security, as well as improve occupant satisfaction. Many of the same smart technologies used in the smart home are deployed in smart buildings, including lighting, energy, heating and air conditioning, and security and building access systems.

For example, a smart building can reduce energy costs using sensors that detect how many occupants are in a room. The temperature can automatically adjust, putting cool air on if sensors detect a full conference room, or turning the heat down if everyone in the office has gone home for the day. Smart buildings can also connect to the smart grid. Here, smart building components and the electric grid can "talk" and "listen" to each other. With this technology, energy distribution can be managed efficiently, maintenance can be handled proactively and power outages can be responded to more quickly.

Beyond these benefits, smart building can provide building owners and managers the benefit of predictive maintenance.

Janitors, for example, can refill restroom supplies when sensors monitoring the soap or paper towel dispensers indicate low. Or maintenance and failures can be predicted on building refrigeration, elevators and lighting systems.

2 Smart home devices

At present time there exist a lot of home appliances that are referred as smart appliances because they provide additional intelligence (functionality) they are equipped by various communication interfaces and applications. In this chapter we mainly concentrate on smart TVs, set-top boxes and smart kitchen appliances.

2.1 Smart TVs

Smart TVs differ from standard TVs in several features. In addition to ability to receive TV broadcasting like any other TV set they are able to make Internet accessible for users thanks to their technical equipment the other TV sets don't have [7].

They run a complete operating system with a graphical user interface (Fig. 3) which enables users to access web space where they can browse web pages via web browser with the same effect like via standard personal computer. It means that TV viewers can watch multimedia content from Internet without a need to watch standard (linear) broadcasting. Of course the web browsing is not very comfortable via a remote control and therefore smart TVs offer a functionality to connect various wireless devices. Currently, there are several possibilities how to control smart TVs (Fig. 4) and they include:

- standard button based remote control, in some cases enhanced by a touchpad or QWERTY keyboard,
- wireless QWERTY keyboard and mouse (application control),
- voice (commands) recognition (e.g. via a microphone in remote control),
- gesture recognition (via connected/integrated webcam),
- smartphone control.

Very important ability the smart TVs provide is an ability to play multimedia content (pictures, audio and video files) because they support most common formats of these media.

Each TV set is equipped by at least one USB interface in some case even by a memory card reader. User can just plug in an USB stick or hard drive or memory card with multimedia content and watch it on big screen. In case a TV set doesn't support some media format or resolution it is possible to connect e.g. laptop to a TV set via HDMI port. TV sets that are **DLNA** (*Digital Living Network Alliance*) certified are able to play multimedia content from other DLNA devices (PCs, tablets, smartphones, media servers, etc.).

Fig. 3 Example of smart TV set

Smart TVs usually contain at least one integrated digital tuner for reception of terrestrial broadcasting (in HD resolution). They are often equipped by other tuners for satellite or cable television. Since they receive a digital television signal they can provide users with recording function so users can record broadcasting on external USB sticks or hard disk drives. Recording function only works from integrated television tuners not from external sources (e.g. HDMI ports).

Fig. 4 Examples of various remote controls for smart TV sets

As we already mentioned these TV sets run some operating system so they are a bit similar to standard PCs. Currently, there is a lot of smart TV producers. Smart TVs can be based on proprietary (closed) or open (source) platform. The most widely known platforms are: Android TV by Google (Philips, Sharp, Sony), Firefox OS (Panasonic), Roku TV (JVC, LG, Sharp, Hitachi) and Tizen OS (Samsung). In addition to web browsing, as was mentioned above, users can run various applications on the smart TV set. Some of them are already preinstalled other applications can be downloaded by users and installed. All of these applications are web based applications. Smart TV applications cover:

- simple Internet browser,
- social networks,
- video online services (YouTube, Vimeo),
- news applications,
- simple games,
- videoconferences (Skype),
- paid video and audio streaming services (Netflix, Spotify, …).

As can be partially seen in Fig. 5, the smart TVs support Ethernet, Wi-Fi, USB and Bluetooth technologies for communications, memory card reader, coax cable (for antenna) and HDMI (eventually older video signal standards) ports, digital audio input and slot for a CI/CI+ module (for smart/subscription cards).

Fig. 5 Rear side of a smart TV

During evolution of smart TVs an important security aspect has appeared. For example in 2013 at Black Hat conference SeungJin Lee showed how is possible to develop an efficient eavesdropping device from smart TV set and cameras and microphones connected to it [8].

2.2 Smart set-top boxes

If you own a TV set that doesn't support smart functions but you don't want to replace it by a new (more expensive) smart TV you can purchase an external smart device called set-top box that provides you with these smart functions. The smart set-top box is able to offer users all functions of smart TVs [9], [10]. Of course it is necessary to connect it to a TV set.

It means that using the smart set-top box it is possible to:

- watch broadcasting (the most often of satellite television; eventually terrestrial or cable television) in *high definition* (**HD**) quality,
- record live broadcasting on internal or external storage (USB sticks or drives),
- play multimedia content from external storages (support for video formats: MP4, MKV, MOV, MPG, MTS, TS, VOB, WMV, XVID, M2TS, AVI, ASF, audio codecs: MP3, WAV, AAC, FLAC, M4A and picture codecs: JPEG, BMP, GIF, PNG),
- receive and watch streamed video using (Ethernet or Wi-Fi) connection to LAN and Internet and even transmit streamed video in some cases,
- run and use preinstalled applications (web browsing, access to social networks, communications, news, etc.), be able to update them and install many others.

Smart set-top boxes can be controlled in the similar way like in case of the smart TVs.

Fig. 6 Examples of set-top boxes

2.3 Smart (kitchen) appliances

As was already said earlier, the smart home is a home that contains smart appliances, i.e. appliances which are equipped by wireless interface and which can be remotely controlled [11]. Wireless interface can be realized by Wi-Fi, Bluetooth or NFC technologies. Smart appliance remote controlling is performed by a smart phone or tablet application that also provides information about appliance status. At the same time smart appliances can warn users of various operation events. Applications for smart appliance control are most often available for Android OS and iOS. Applications are often developed by each smart appliance producer or the producer builds its own ecosystem with one application able to control a set of producers' smart appliances. Certain group of electronics producers is developing Home Connect platform which enables users to communicate with smart appliances of different producers. Currently, this platform is supported by appliances of Bosch and Siemens. Other partners are e.g. Amazon Alexa, Nest or IFTTT [12].

If an ordinary home appliance could become smart except for a wireless interface it needs a set of sensors which define functions and abilities, what can be done with that appliance. At present time there exist following smart appliances and functions they support:

- smart fridges - temperature set up, control of other functions, remote view to the fridge via integrated panoramic camera. LG introduced a fridge with virtual intelligent personal assistant Alexa developed by Amazon who the users can talk to and except for standard commands they can tell her, what foodstuffs and when she should order. The fridge is equipped by a 29" touchscreen depicting content of the fridge and foodstuffs with close expiration date. It is connected to social networks and it can warn a user of friend birthday [13].
- smart ovens - information about appliance status and baking process, temperature or programme change.
- smart dishwashers - dishwasher activation, suitable programme recommendation, washing process monitoring, information about number of tablets in a dispenser.
- smart washing machines (dryers) - programme, water temperature and spin speed set up, washing process monitoring.
- smart coffee makers - coffee brewing, selection of a programme.
- smart vacuum cleaners - activation of cleaning, notification of completion, taking control (it is possible to play with a vacuum cleaner like with remote control cars).

It is clear that smart appliance assortment will extend. We can await smart toasters, cookers, kettles, forks, pans, weighting machines, grill machines, etc. Griffin company even offers a futuristic mirror that can show you e.g. weather forecast, world news or oncoming events during morning make-up or teeth cleaning.

3 Smart end user devices

In this chapter we characterize smart electronic devices which are carried or worn by end users. It relates to smartphones, smart watches and glasses.

3.1 Smartphones

The most widespread smart device today is for sure a smartphone that represents a portable (handheld) personal computer. Except for basic function - telephoning - it provides large amount of other functions. It is connected not only with its high computing power but also with support for wireless communication (in addition to mobile network access it is equipped by Wi-Fi and Bluetooth interface and in some cases by NFC). Via wireless interfaces smartphones are able to communicate with other smartphones, smart watches or glasses, or even with smart TVs and computers. Smartphones dispose of a number of sensors (Table 1) that even more extend a portfolio of possible applications [14].

Table 1 The most used sensors in smartphones

Sensors	**Measured parameter**
Accelerometer	Acceleration
Gyroscope	Orientation and angular velocity
Magnetometer	Magnetic field
Barometer	Atmospheric pressure
Distance sensor	Object distance from a smartphone
Light sensor	Light conditions
Touch screen	Finger touch
GPS	Position on Earth
Front and rear camera	Picture
Microphone	Sound

Fig. 7 Examples of smartphones

Smartphones provides high speed access to Internet via mobile or Wi-Fi interface. They are equipped by (SD) memory card reader and USB interface. They contain a mobile operating system that enables users to run and use huge number of applications.

These applications allow user to use following functions and services:

- telephone calls, SMS/MMS, email, online text, voice a video chat,
- taking pictures and videos, audio recording,
- satellite navigation, compass, trip planner, weather forecasting,
- multimedia content playing, reading and editing documents,
- web browser, news, educational courses, event calendar, address book, mobile payment, notes,
- clock, alarm clock, notifications, alerts (including vibration), calculator, flashlight,
- virtual assistants (Apple Siri, Amazon Alexa, Google Assistant, Microsoft Cortana, BlackBerry Assistant, Samsung Bixby),
- games and many others.

In Fig. 8 a simplified logical diagram of a smartphone is depicted [15]. The smartphone basis comprises from two to eight core processor (up to 2.8 GHz), graphical processor, RAM up to 8 GB and Flash memory up to 256 GB, modules with wireless interfaces, up to 6” touch screen (LCD, IPS, LED, OLED or AMOLED) display (with up to 3840x2160 resolution), various types of sensors, and that all powered by a rechargeable lithium-ion or lithium-polymer battery with a capacity up to 4000 mAh. Cameras for still pictures with up to 20 MPx resolution and video up to 16 Mpx are inseparable part of smartphones. Currently, there are on a mobile operating system market two leading representatives namely Android from Google (with open course) and iOS from Apple (proprietary). The other currently developing operating systems are e.g. Tizen (Samsung) or Sailfish (Jolla). In 2017 (first quarter) Android OS dominated on the market. 86.1 % of all smartphones run Android OS and 13.7 % run iOS [16].

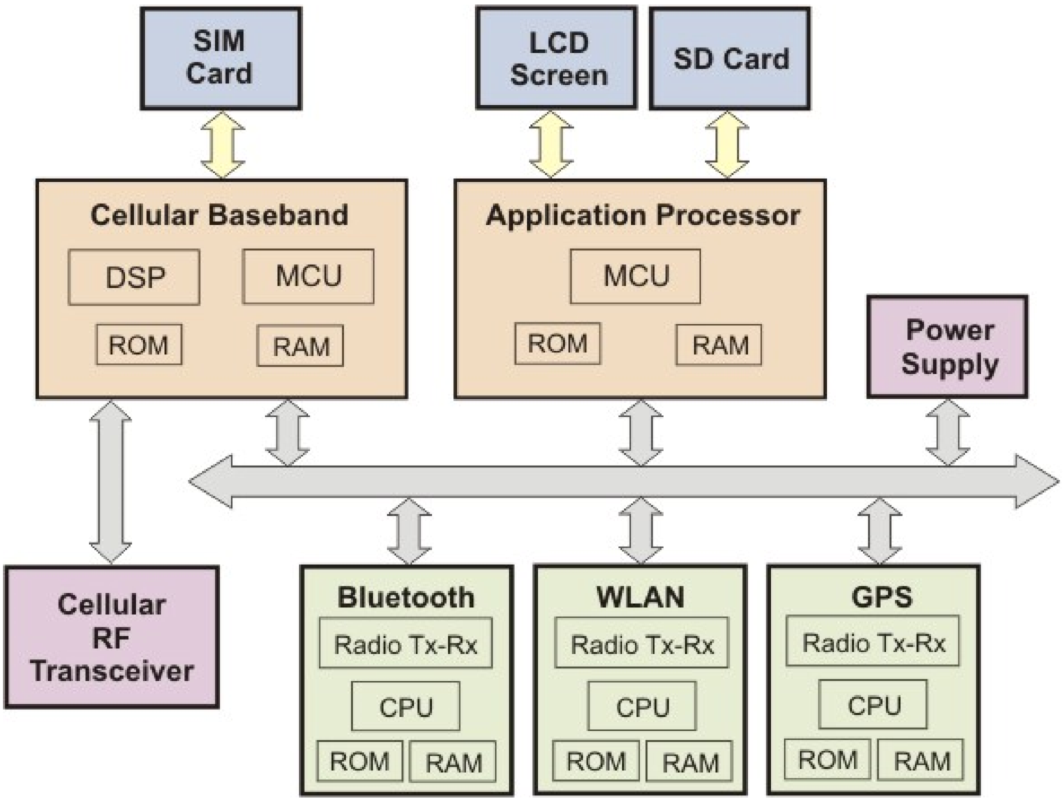

Fig. 8 General/simplified logical diagram of a smartphone [15]

3.2 Smart watches

Smart watches are devices which provide similar functions like smartphones. In general, they are small computers in the form of a wristwatch or bracelet. They are able to work on their own or they can synchronise with a smartphone via Bluetooth and provide even more functions [17]. Except for Bluetooth interface they can be also equipped by wireless interfaces such as Wi-Fi, 3G, 4G, LTE, NFC and GPC. These allows them to communicate with external devices like sensors of various types (thermometer, heart rate meters/monitors, accelerometers, altimeters, barometers, pedometers, compass), speakers, headphones with microphone, head-up display devices, and of course with smartphones, tablets, etc. Some these sensors can be integrated inside smartwatches (e.g. GPS sensor, heart rate sensor). Smartwatches can collect data from internal as well as external sensors, process them and provide them with users in required form.

Fig. 9 Examples of modern smart watches

Besides the basic functions provided by standard watches such as actual time (and date), calculator, translations and games the smart watches offer functions as follows:

- telephoning,
- email, instant messaging,
- web browsing (even by voice commands),
- appointment schedule,
- various types of notifications (e.g. phone call notification),
- GPS positioning (e.g. during sport activities),

- payment in stores (virtual wallet),
- and many others.

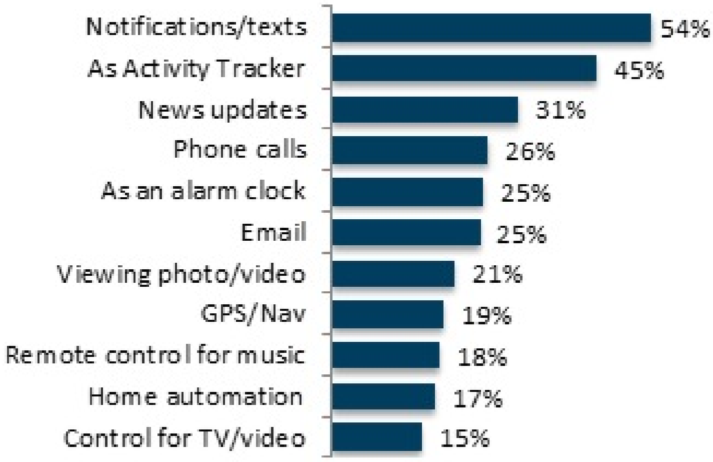

Fig. 10 Overview of most often used functions on smart watches according to [18]

Smart watches often serve as a prolonged arm (screen) of smartphones because a lot of actions can be done without touching or even removing smartphone from a pocket. During synchronisation of smart watches with a mobile device compatibility is very important. There are watches which use own operating system (e.g. Pebble OS, Wear OS, Fitbit OS, Tizen OS) but they are able to cooperate with devices running Android OS or iOS. At the other hand there are watches (e.g. with watchOS or Android Wear) which are able to communicate only with devices running the same OS (e.g. from Apple).

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Disadvantage of these devices is a low battery life (time). Many companies try to provide at least an innovative smart watch charging method. Except for standard charging via the USB interface there are available smart watches which can be charged wirelessly (e.g. Moto 360 watches from Motorola) or using an charging dock/cradle (e.g. G Watch R from LG). Nevertheless, low battery life still persists and in general it is valid that most of true smart watches hold for one or two days.

There are exceptions such as Vector Watch Luna, Garmin Vivoactive or TomTom Spark 3 Cardio + Music with battery lifetime higher than 20 days [19].

In Fig. 11 a general block diagram of smart watches is depicted. The smart watch heart is based on an application processor (with up to 4 cores and a frequency of 1 GHz) equipped by internal memory (e.g. RAM of 512 MB and Flash of 4 GB) that communicates with internal sensors and external sensors via a wireless (radio) transmitter/receiver and that depicts information on touchscreen (most often OLED, LCD, LCD e-paper) display with resolutions from 128x128 to 360x480. Smartwatches are usually powered by lithium-ion battery. Among 50 companies participated on research and development of smart watches we can mention e.g. Apple, LG, Sony, Pebble, Samsung, Motorola, Google.

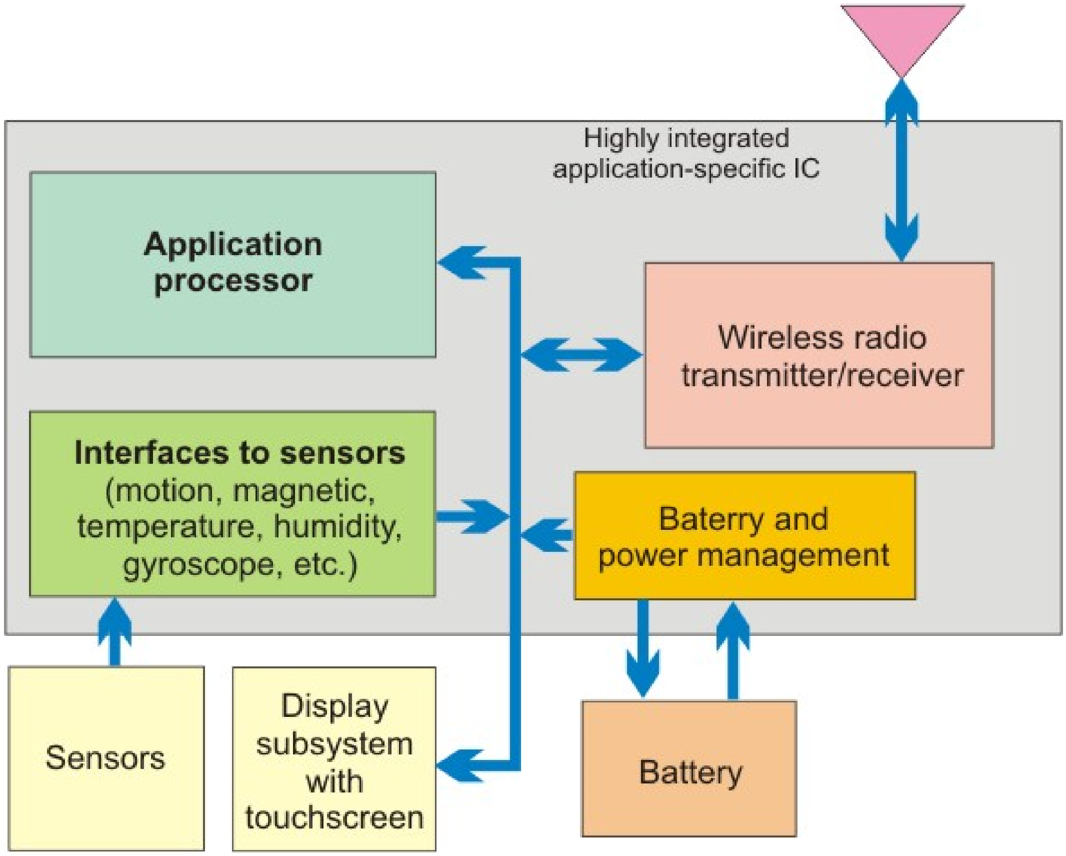

Fig. 11 General block diagram of smart watches [20]

3.3 Smart glasses

Smart glasses belong just like smart watches among so called wearable devices and integrate a computer and glasses into one device. Required information is provided via integrated display or directly into a picture the user can see via glasses [21]. There exists a specific group - smart sun glasses - glasses which changes their optical (light filtering) properties (tint) according actual lighting conditions. There are several methods how to show a smart glasses user required information:

- via *optical head-mounted display* (**OHMD**) - e.g. Google Glass,
- via integration of wireless glasses with a transparent *heads-up dis*play (**HUD**) - e.g. Solos glasses,
- via *augmented rea*lity (**AR**) overlay with a real picture (using mirroring a projected picture) - e.g. Vuzix Blade,
- via a laser that projects a tiny image directly onto the corner of users‘ retina - a new technology introduced by Intel in Vaunt glasses.

Functions which are provided by smart glasses to a large extend depend on purpose they are developed (security, healthcare, entertainment, etc.). Smart glasses can be equipped by wireless technologies such as Wi-Fi, Bluetooth, GPS and mobile network access eventually. For example they can only provide information on glasses screen from a remote system in some cases with audio (they can work like a portable media player). More enhanced glasses can offer a set of mobile applications. Smart glasses can be controlled by buttons, smartphone, voice commands (if a microphone is integrated), gestures or eye motion (if a camera is integrated) and in future maybe by a *brain-computer interface* (**BCI**). Like smart watches the smart glasses can also gather data from internal and external sources.

Fig. 12 Examples of smart glasses

4 Smart cities and communities

What is a Smart city? There exist several definitions, but more of them include that it is an urban area that uses different types of electronic data collection sensors which provide information, that is then used to efficiently manage city assets and resources.

The smart city concept integrates *information and communication technology* (**ICT**). The data provision often occurs through IoT networks. Smart city technology allows interaction with both, community and city infrastructure and to monitor what is happening in the city and how the city is evolving. According to the analyses [22], [23], e.g. Singapore and Barcelona belong among the smartest cities in the world. Singapore is considered as leader when looking only at transportation. Both operate an open data platform related to data collected by sensors. Many of smart cities are using cloud-based services in their solutions. Technological solutions mostly use the concept of „big data“ system, designed to manipulate (capture, store, analyse, query, visualise) huge amount of data. The smart city functional domain splits up according to IEEE [24] as follows:

- Sensors and Intelligent Electronic Devices,
- Communication Networks & Cyber Security,
- Systems Integration,
- Intelligence & Data Analytics,
- Management & Control Platforms.

Based on these functional domains there are built the Smart city solutions for specific topic. Some of the most essential ones are covered in the following sections.

4.1 Intelligent transport systems

Intelligent transport systems (**ITS**) aim to provide innovative services and traffic management enabling the users to be better informed and making the transport networks safer, faster and more efficient. This in turn minimises pollution and other negative aspects of transportation networks.

There are various systems belonging to the intelligent transport systems from basic management systems such as car navigation; traffic signal control systems; variable message signs; to more advanced applications that integrate live data and feedback from a number of other sources, such as parking guidance. Smart cities need ITS. A well planned and efficiently managed transport network is a must for any society.

Important features of Intelligent Transportation Network include:

- Public Transportation Management - the aim is the encouragement of public transport usage amongst people. This can be achieved by effective automation, planning and information. Especially Multi-Modal transportation options shall be integrated to make public transportation attractive and effective.
- Route Information and trip planning - the aim is to give the travellers information about the route best suited for their journey and giving them instructions and additional information (e.g. estimated travel duration, alternate routes, toll fares, etc.). The real time information about traffic conditions along the route are also taken in account.
- Safety and Vehicle Control - the aim is to provide safety assistance to vehicle operators, giving them additional information about surrounding environment (e.g. collision warning by tracking position of other vehicles, etc.).
- Electronic Timetable - they can assist travellers in knowing the arrival and departure time, delays, transfers and connections at a station.
- Electronic Payment System - the consumers don't have to waste time in buying tickets for different modes of transport. They can make one single electronic payment and obtain one fare card to cover different modes of transportation.
- Smart Parking - solutions with the help of right infrastructure can minimize parking woes (that affect every city dweller) to a great deal.
- Mobility as a service - it is important to provide mobility as a service as an option, e.g. using transportation network companies (Uber, Lyft, ...), car sharing, bike sharing, etc.

The most important ITS technology enablers are tracking systems (e.g. GPS), intelligent sensors in vehicles and road infrastructure (including cameras and video analytics) and intelligent traffic light system.

One of novel applications in ITS is Emergency vehicle notification system (eCall) which was made mandatory in all new cars sold within the EU from April 2018. In case of activation of in-vehicle sensors after an accident the eCall device will establish an emergency call carrying both voice and data directly to the nearest emergency point.

4.2 Intelligent video (surveillance) for a safe community

With growing security concerns in daily life, improved video surveillance has become an urgent priority for both the public and private sectors. Whether in airports, banks or factories video surveillance systems are an essential tool to fight crime and provide safety. Nowadays there exist many scales of surveillance systems (from Home surveillance systems, city wide systems to national wide systems). Their intelligence varies as well. Even simple cameras have in many cases built in features such as motion detection, moving object counting, etc. If the camera does not have it built in, connecting the camera to video analytics systems does the job as well. Two of the most important aspects of smart cities are intelligent security and surveillance. With video analytics, remote and unmanned monitoring is possible. For example, there would be no need for manual monitoring, or unattended object detection, or for securing valuable assets, or for illegal parking, or for intruder detection. All this can be efficiently and automatically done by using configurable video analytics which can help in the reduction of false alarms, and leveraging real time custom alerts so that proper and timely action can be taken. This can also be applied in many other cases such as crowd monitoring, people counting, vandalism, queue management, and more. Face recognition systems can help to reduce criminal activities by helping to nab criminals faster.

These technologies can be also applied to traffic area to enhance the safety, either as assistive technology for the driver (wrong way, speed zones) or e.g. in enforcements systems using license plate recognition it could help to reduce traffic rule violations.

4.3 Smart metering and smart energy systems

Smart metering refers to metering based on smart meters. The term Smart Meter often refers to an electricity meter, but it also may mean a device measuring natural gas or water consumption. The smart meters were introduced in 2009 to simplify the billing process and to ensure that readings were up to date and accurate.

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The smart meters differ from non-smart meters mainly in following points, they:

- except for total consumption also provide the information when the energy was consumed. Then billing can be based on near real-time consumption rather than on estimates based on past or predicted consumption and utility providers and their customers can better control the use and production of electric energy, gas usage and water consumption.
- provide power outage notification, power quality monitoring, security related notifications (e.g. manipulation with the device), etc.
- allow bidirectional communication for software updates, tariff calendar updates, switch on/off, time synchronisation, etc.

The first above point also satisfies the devices for *Automated Meter Reading* (**AMR**) or Data Loggers. But they offer the features mentioned in further points and provide significant added value with regard to simpler devices. The systems that use smart meters are referred as *Advanced Metering Infrastructure* (**AMI**). The smart meters mostly communicate with the distributor company wirelessly using DLMS/COSEM (IEC 62056 standard) protocol. **COSEM** stands for *Companion Specification for Energy Metering* and **DLMS** stands for *Device Language Message Specification*. DLMS/COSEM protocol is not specific to electricity metering, it is also used for gas, water and heat metering. All transferred data are identified by **OBIS** (*OBject Identification System*) codes. Another frequently used communication option is using **PLC** (*Power Line Communication*) and *Data Concentrators* (**DC**).

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Though smart metering provides many technological benefits there are more concerns that decrease its overall acceptance:

- health concerns - they arise from the radiofrequency radiation emitted by wireless smart meters - the electromagnetic pollution would be smaller without them.
- safety concern - in recent years many issues related to smart meters causing fires were reported.
- privacy - the meters send detailed information about consumption to the provider. From these data providers could derive a lot of sensitive information with high accuracy and precision (as which electronic device is currently operating, is somebody at home, etc.) so there is a certain risk when data are stolen or inappropriately used.

- lack of savings in results - some pilot cases showed that when providers offer the users price reduction when they will not consume the electricity in the peak, only few of them used it. The people barely check their energy data as the process is difficult for them.

Nowadays, the smart metering systems are introduced worldwide, when designed carefully they provide undisputable benefits to all participating entities.

Smart meters play also important roles in the smart grids. A smart grid is an electrical grid which includes a variety of automated operational and energy measures for power monitoring and control related to production and distribution of electricity. Smart grid is characterized by the following [25]:

- self-healing,
- consumer friendly,
- resistant to physical and cyber attacks,
- optimized asset utilization,
- eco-friendly,
- the use of robust two-way communications, advanced sensors and distributed computing technology,
- improved efficiency, reliability and safety of power delivery and use.

One of the standards for Smart Grids is *Open Smart Grid Protocol* (**OSGP**), which is a family of specifications published by ETSI for reliable and efficient delivery of command and control information for smart meters and other smart grid devices. Another standard is OpenADR - an open-source smart grid communications standard used for demand response applications. It is typically used to send information and signals to cause electrical power-using devices to be turned off during periods of higher demand.

In the smart grid concept the microgrids play an important role. A microgrid is a localized group of electricity sources and loads that normally operates connected to and synchronous with the traditional wide area grid (macrogrid), but it can also disconnect to "island mode" and function autonomously. A microgrid can effectively integrate various sources, especially *Renewable Energy Sources* (**RES**), and can supply emergency power, changing between island and connected modes. While smart grids take place at larger utility level such as large transmission and distribution lines, microgrids are smaller scale and can operate independently from the larger utility grid. Even more [26], microgrids however offer an alternative path for smart grid development. They comprise almost all components of a larger grid - but are much smaller and usually locally-owned and operated. With microgrids, it is significantly less difficult and costly to deploy smart technologies, so they could become the incubators and a means to transform the current electric grid into a system that meets future electric demands, efficiency and reliability.

In recent years, the terms “Smart Energy” and “Smart Energy Systems” have been used to express an approach that reaches broader than the term “Smart grid”. Where

Smart Grids focus primarily on the electricity sector, Smart Energy Systems have a holistic view on more sectors (electricity, heating, cooling, industry, buildings and transportation) allowing the identification of renewable and sustainable energy solutions. Smart Energy System concepts show how to benefit from the integration of all sectors and infrastructures [27]. Basically, they are built around three basic grid infrastructures:

- Smart Electricity Grids - connect flexible electricity demands (heat pumps, electric vehicles, ...) to the renewable resources (wind and solar power, ...),
- Smart Thermal Grids (heating and cooling) - connect the electricity and heating to enable the utilisation of thermal storage,
- Smart Gas Grids - connect the electricity, heating, and transport sectors to enable the utilisation of gas and liquid fuel storages.

4.4 Smart waste management

The aim of Smart waste management is to reduce the amount of time and energy required to provide waste management services using smart technologies. One big problem that public services and waste management companies are faced is that they need to physically go to the dumpster to check trash levels. Because of this, trucks often visit containers that do not need emptying, which wastes both time and fuel. Route optimization solves this problem only partially. With the rise of the Internet of Things, smart sensors and sensor-level M2M technology the optimisation of routes can make significant step forward. The garbage receptacles can “talk” to the waste management company and tell them whether the container is at full capacity, when it needs to be emptied, what temperature the container is at, etc., allowing the company to work more efficiently and cut unnecessary costs. Additionally, the sensors can help the company to forecast when a dumpster will be full, allowing them to plan ahead future routes.

Smart technologies can also decrease amount of waste indirectly. E.g. in the U.S., consumers waste about 30%, or 133 billion pounds of food each year [28]. This could be dramatically reduced with the asset and material tracking. Using the right IoT technology, a store could better track exact quantities of the food they sell, cut back on waste, and reduce spoilage. From a consumer perspective, this technology can be extended into home e.g. using smart refrigerators which could alert the consumers when their food is going to spoil, hinting to consume it before it goes bad.

4.5 Intelligent lighting

Connecting street lights together in a computer-controlled network opens the door to a wide range of innovative capabilities that save energy and improve the performance of the lighting system. Beyond those applications there is an option to deploy the non-lighting solutions on the lighting network, making it a ubiquitous platform for smart city applications. The lighting functions include:

- Basic functions - remote on-off control, dimming, and scheduling functions.
- Energy monitoring - accurate information on energy consumption can be used for optimization and grid management.
- Colour control - lighting may be adjusted for public safety purposes, or to fit e.g. special events, etc.
- Adaptive lighting - Motion detectors can enable lighting levels to match street activity (e.g. brightness can be reduced if no traffic is present). Weather sensors can also enable adaption to rain, snow, or other conditions (e.g. lights may be turned on during rain showers and back down when the weather clears).
- Emergency response - there is a number of features for dealing with public safety issues and emergencies, such as flashing lights in front of a house that emergency workers are attempting to find, brightening lights at an accident or crime scene, use of adaptive light controls to provide warnings to drivers in school safety zones, etc.

Besides the capabilities for advanced lighting controls, street lighting has potential to wide range of Smart city applications as:

- Environmental/air quality monitoring - air quality and noise sensors can be easily deployed on street lighting poles.
- Traffic monitoring - mounting of traffic sensors can provide a more accurate and flexible monitoring of traffic.
- Smart parking - mounting of parking sensors or video cameras with vehicle detection software can provide occupancy information.

Besides this, the lights can provide the network connectivity service itself e.g. using WLAN.

Interesting use case in emergency area is e.g. mounting of „panic“ button on the pole [29]. In case of any emergency or danger, the person can press this button which raises an alarm at the nearby police station. A camera can be placed on top of the street light to track these cases as well. There exist concepts [30] that use „panic“ button in mobile applications, causing the street light starts to blink, attracting the attention of people around, which could also help.

5 Robotics and smart machines in enterprises

Smart machines are a subset of artificial intelligence that can teach themselves how to do things and perform tasks. These machines are moving toward digital, using artificial intelligence and machine learning to its full potential. *Artificial intelligence* (**AI**) is what makes these machines to appear intelligent and provides the framework for smart machines to function. Smart machines include robots, self-driving cars and other systems that are designed to work through tasks without human intervention. In business such technologies are expected to bring higher profit margins and lead to more efficient manufacturing processes. However, smart machines are also expected to displace workers and dramatically change the nature of work and other societal norms. Today's smart machines might seem revolutionary, like something in science fiction movies (like C-3PO in Star Wars). However, smart machines are the next step in a long history of incremental advancements in machines and computing. Smart machines could trace their roots back to the first Industrial Revolution (the 18th century), when the rudimentary machines were used to automate some human tasks. The advent of computers in the 20th century together with rise of Internet of things, data storage systems and sensors enabled collection and analysis of huge data volumes, further speeding the rise of smart machines. Such huge data volumes can be effectively exploited using data analysis methods. **Big data** analytics refers to a method for gathering and understanding large data sets in terms of what are known as the three V's, velocity, variety and volume. Velocity informs the frequency of data acquisition, which can be concurrent with the application of previous data. Variety describes the different types of data that may be handled. Volume represents the amount of data. Data can be also exploited by *business intelligence* (**BI**) and **advanced analytics**, whereby computers run algorithms to analyse data to identify patterns and then to use those patterns to generate insights into past and current events and, later, to offer insights on what would happen and what could happen if certain future actions were taken. This analytics capability, in turn, led to machine learning and deep learning, where computers themselves actually learn from additional data sets; more to the point, these smart machines use their new knowledge to adapt and adjust their output.

In medicine area, a lot of other people are talking about how to get an AI / computer with machine learning algorithms to diagnose patients or to replace physicians, but it is about augmenting the physician, to use the computer as a tool rather than a replacement. E.g. in experiments [31] when a patient is triaged by a nurse, the data captured is run through a predictive analytics engine, which determines the top five chief complaints a patient most likely has. The program has improved collection rates of chief complaint data dramatically - from 25% to 95%.

Robotics is a type of engineering that is behind the design and operations of robot machines that can perform tasks without human aid. This is one tool under the umbrella of smart machines. According to Gartner, they must be able to:

- adapt their behaviour based on experience (learning),
- not be totally dependent on instructions from people (learn on their own),

- be able to come up with unanticipated results.

Learning on their own in a variety of different environments has set robots up to be vital tools in some leading industries. Among these are:

- Healthcare - robots have been seen in different areas of the healthcare industry such as surgical care and doctors tasks. The evolution of healthcare involves robots in a major way and experts say it is only going to expand. Robots are seen in surgical care because they provide the precision, flexibility and detail focused manpower that assists doctors in order to make surgeries seamless and effective.

- Finance - financial services use robotics in order to carry out different operations. Robo-advisory firms have become the future of banking. They simply use unique and sensitive algorithms that provide services such as financial advice and portfolio management. These firms offer customers a personalized experience and bridge the divide between financial services and digital. Forbes agrees.

- Rtail - robotics is being applied for in-store customer service. This is seen in a variety of stores who provide interactive tools that customers use in order to shop for a product in the store or to gain access to an employee quickly.

Fig. 13 Baxter, robot, Rethink Robotics

When deploying the robots in the industry, there is important problem - the **human-robot barrier**. In most cases now, robots working on the factory line are kept in cages because they pose too many physical risks to humans, which causes that the human workflow is completely separated from the robot workflow.

There is on-going effort to achieve the human and the robot to train together, to create a shared understanding of how to work together and be more efficient. An early example is the Baxter robot built by Rethink Robotics. Baxter, built in a human form, can work right next to line employees on the factory floor - without a cage. Several factories have deployed Baxter to perform "dull jobs" - highly repeated tasks such as precision packing. Baxter is equipped with sensors that enable the robot to "feel" and "see" so it can adapt to its environment. It is not needed to tell him how fast a conveyer belt is moving; he sees it; he knows it and has common sense to figure that out. As robots become more integrated into the workflow, as smart machines begin to share a business process with humans, the data they absorb and generate becomes more important to the enterprise.

A new powerful element on the robotics and smart machines area is **Cognitive Computing**. It is clear that technology in robotics is moving toward innovative tools that use self-learning techniques in order to carry out tasks. Cognitive computing is among those tools that have been a disruptive force in the industry of smart machines. “Cognitive computing is based on self-learning systems that use machine-learning techniques to perform specific, human-like tasks in an intelligent way.” Cognitive computing stays true to what smart machines consist of - a form of artificial intelligence that allows us to make sense of the data that is processed through systems. It runs through a large amount of data that would take humans an immense amount of time to do. It then finds and creates actionable data instead of raw data, which means businesses can use the information presented in real time. This tool makes it easy for organizations to carry out operations because it gives data a purpose. With so much data being accumulated in the leading industries, using this tool makes the information found actually useful, therefore making systems to excel.

Another important notion is **Smart manufacturing**. It is a broad category of manufacturing with the goal of optimizing concept generation, production, and product transaction. While manufacturing can be defined as the multi-phase process of creating a product out of raw materials, smart manufacturing is a subset that employs computer control and high levels of adaptability. Smart manufacturing aims to take advantage of advanced information and manufacturing technologies to enable flexibility in physical processes to address a dynamic and global market. There is increased workforce training for such flexibility and use of the technology rather than specific tasks as is customary in traditional manufacturing.