**Self-Check Questions**

**Unit 1**

**1.1**

1. Why could smartphones not be established in 1992?

*At that time, cellular networks were not yet designed for data transmission. Even the first web browser was still waiting to be developed. The device was ahead of its time.*

2. What additional technological development was necessary for the widespread introduction of smart devices?

*In 1998, Internet Protocol version 6 (IPv6) was introduced by the “Internet Engineering Task Force” (IETF). In contrast to its predecessor IPv4, the new version had a much larger address space, which meant that significantly more end devices could be addressed than with IPv4. Without this expansion of the address space, the development of smart devices or the Internet of Things (IoT) in the form we know them today would not have been possible.*

3. What are the four evolutionary stages of Industry 4.0?

1. *mechanical manufacturing with steam engines*
2. *electrical mass manufacturing*
3. *electronic mass manufacturing*
4. *fully automated and individualized manufacturing*

**1.2**

1. What does Moore's Law state?

* *The performance of microprocessors doubles every 18 months.*
* *Computer performance doubles every 18 months.*
* *The price of computer-based IT processing halves every 18 months.*

1. Fill in the blanks.

Sensors are components for a *qualitative* or *quantitative* measurement of *chemical* or *physical* quantities and *features*.

1. What major technological challenge needs to be solved for the mobility of smart devices?

*The storage capacity of batteries is a limiting factor for the mobility of smart devices.*

**1.3**

1. What is the Internet of Things?

*The Internet of Things (IoT) puts information into the physical world. Objects and places become part of the IoT in two ways. Firstly, information can be linked to a specific location (by means of GPS coordinates or addresses, for example). Secondly, the connection of smart devices, equipped with sensors or actuators to the Internet, enables so-called IoT applications.*

1. Which industrial sectors can the Internet of Things be grouped into?

![Timeline

Description automatically generated]()

1. What does Maslow's Hammer say and how does it relate to IoT?

*The Law of the Instrument* – *also known as "Maslow's Hammer”* – *states “that people who are well versed in one tool or approach tend to use that tool even when another is more appropriate”. Technology should be a means to an end, not an end in and of itself. More IoT applications can be developed than are needed.*

**Unit 2**

**2.1**

1. Which five characteristics can be used to classify smart devices?
2. *Ubiquity/omnipresence*
3. *Embedding*
4. *Intuitive interaction*
5. *Adaptivity*
6. *Proactivity*
7. How can smart devices be classified?

|  |  |  |
| --- | --- | --- |
| *Device shape* | *Size* | *Features* |
| *Tabs* | *< 10 cm* | *Concealable* |
| *Pads* | *10 cm < 100 cm* | *Portable* |
| *Boards* | *> 100 cm* | *Installable* |

1. What are highly miniaturized smart devices called?

*MEMS* – *Micro-Electro-Mechanical Systems*

**2.2**

1. What are smart watches?

*A smart watch is a mostly digital and “smart” wristwatch with a small display that can be operated similarly to a smartphone. In addition, a smart watch can be connected to a smartphone via Bluetooth, for example. In addition to the display of time and date, various additional information can be displayed. This can include incoming messages, e-mails, calls, or other notifications (push notifications). Sensors can also be used to measure various data, for example, pulse, step rate, or position and transmit them to the smartphone. The latest smart watches have integrated SIM cards. This allows the watches to send and receive messages directly, make calls, or receive notifications, even if it is not connected to a smartphone.*

1. What are smart glasses?

*Data glasses, also called smart glasses, superimpose information in the user's field of vision. They are small computers in the form of eyeglasses, in other words, computers attached to eyeglass frames. Such glasses are comparable to smartphones in terms of performance. They use mobile apps independently, take and display pictures and videos, and collect and retrieve information. With data glasses, a distinction is made between augmented reality (AR) and virtual reality (VR). With AR, contextual information about the environment is displayed directly above specific objects. AR data glasses are very rarely seen in consumer electronics today for a variety of reasons.*

1. What are smart clothes?

*As hardware becomes smaller and smaller, electronic functions can now be incorporated into clothing. In the past, only a few applications were possible. Nowadays, there is a wide range of intelligent textile products, also called “smart clothes” or “wearables”. Smart clothes have already made inroads in the five markets of health, safety and security, information and communication, sports and leisure, and work and surveillance.*

**2.3**

1. What are Micro-Electro-Mechanical Systems, MEMS for short?

*Micro-Electro-Mechanical Systems, or MEMS, are tiny integrated devices or systems that are created using a special manufacturing technology that combines mechanical and electrical components. MEMS are usually very small, and their components can only be seen through a microscope. Today, levers, gears, pistons, engines, and even steam engines have already been manufactured. MEMS are manufactured using stacked integrated circuit (IC) processes and can range in size from a few micrometers to a few millimeters.*

1. Which markets are MEMS found in?

*MEMS are used in systems that are applied in the automotive, medical, electronics, communications, and defense sectors.*

1. What are the two revolutions in microfabrication?
2. *Semiconductor micro-fabrication*
3. *MEMS*

**2.4**

1. What purposes do smart home devices serve? Name three aspects.

* *Making residents’ everyday lives easier, safer, and more energy-efficient*
* *To network devices and building elements*
* *Central control unit*

1. Why is there a higher demand for data integrity and data security in the use of smart devices in the medical sector?

*In clinical operations, there are much higher demands on data integrity and security since personal data can be processed here. Such data is subject to special legal regulations.*

1. What effect will networked smart meters have in the energy market of the future?

*In the smart energy market of the future, analog electricity meters will be replaced by networked smart meters. These smart meters offer added value for customers and electricity suppliers. Customers can access current electricity consumption in real time using a web application. Electricity suppliers can use the consumption data to react more quickly to consumption peaks and, thanks to the data obtained, develop better models for forecasting electricity consumption. With analog electricity meters, a classic, centrally controlled system with passive consumers is possible. Using smart meters, a decentralized system with active integrated consumers is possible. In such a system, consumers can also become producers.*

**Unit 3**

**3.1**

1. What is a processor and what components does it have?

*A central processing unit, as a processor, is the electronic circuitry in a computer that executes the instructions of a computer program by performing the basic arithmetic, logic, control, and input/output operations specified by the instructions.*

*Main components of a CPU include...*

* *the arithmetic logic unit (ALU), which performs arithmetical and logical operations*
* *the processor register, which supplies operands to the ALU and stores the results of ALU operations*
* *a control unit that controls retrieving (from memory) and execution*

1. Why does a new generation of processors have to be developed for smart devices?

*Power consumption plays a very important role for networked and embedded applications. A new generation of “low-power” processors is being developed for such applications.*

1. What makes this new generation stand out?

*In addition to power consumption and other aspects, reliability is also an important issue in the development of processors for smart devices.*

**3.2**

1. How does a normal sensor differ from a smart or intelligent sensor?

*A normal sensor does not need smart electronics to function. The results of the sensor are converted in direct relation to the measured values. A smart sensor has an integrated chip and can respond differently to different environments and adapt to its surroundings.*

1. What conditions must apply so that integration of the processors of smart sensors is desirable?

*Integration lowers the manufacturing costs of the sensor.*

Integration lowers the performance of the sensor.

*The sensor would not work without integration.*

*Integration promises high market potential.*

1. Name three classes of sensors and give examples.
2. *Signal compensation: temperature compensating acceleration sensor*
3. *Self-testing: ADC chips*
4. *Multisensing: electronic nose*

**3.3**

1. Which radio interfaces have you got to know?

*WLAN, Bluetooth, mobile communications*

1. How does Bluetooth work?

*Bluetooth transmits in the license-free Industry, Scientific and Medical (ISM) band between 2.40-2.48 GHz. Several Bluetooth-enabled devices communicate with each other via a so-called piconet.*

1. What do the abbreviations LAN and WLAN stand for and what is the difference between them?

*A so-called Wireless Local Area Network (WLAN) is used to establish wireless access to a local area network (LAN). WLAN connections are wireless, LAN connections are wired.*

**Unit 4**

**4.1**

1. What role do LANs play in relation to smart devices?

*LANs are created by connecting various electronic devices within an organization, allowing local processing and simultaneous access to other devices connected to the network (message transmission between stations without the use of a central host computer, access to various file storages, etc.).*

1. What are the risks and advantages of WLANs?

*Wireless networks use air as the medium. This medium is sensitive and omnipresent by its very nature. These are risks, but they are offset by advantages, such as a reduction in costs by saving on cable laying or increased mobility.*

1. What is the range of LANs?

*Several kilometers*

**4.2**

1. What is the meaning of the abbreviation “PAN”? Give examples.

*Personal Area Network. A PAN occurs, for example, when two or more people want to exchange data directly via their carried devices (wireless) without relying on an Internet connection. This can be done, for example, via WLAN, infrared, Bluetooth, but also via a wired USB interface. A PAN also occurs when using wireless headphones or a smart watch connected to a smartphone.*

1. What is the range of a PAN?

*10 to 100 meters*

1. Which three networking topologies regarding PAN have you got to know? Write them down.

* *Star topology*
* *Mesh topology*
* *Cluster tree*

Star topology

Mesh topology

Cluster tree

PAN coordinator

Fully functional device

Semi-functional device

**4.3**

1. What is the meaning of the abbreviation "WBAN"? Give examples.

*Wireless Body Area Network. Wireless networking should be the focus here, as wired networking in this area would be a hindrance in many applications, while in others wireless is necessary for the scenario. When it comes to WBANs, it is important to meet the special demands that arise when telecommunications technologies are used close to the user's body. The first applications of this technology can be found in the healthcare sector, but it is also used in other industries.*

1. What is the focus of WBAN and what does it mean for users?

*In WBAN applications, the focus is on mobility. This means that users can move freely without any connected smart devices restricting their freedom of movement. Energy consumption is also usually especially low. Nevertheless, WBAN devices can implement complex and reliable applications with high device density. These applications are specifically designed to meet the needs of the human body and serve as an interface to other networks.*

1. What smart device requirements for WBAN are you aware of?

*Portability, reliability, security, and interoperability*

1. Can WBANs communicate with PANs and/or LANs?

*Yes*

No

**4.4**

1. What does "IoT" stand for and what does it mean?

*Internet of Things (IoT) is a concept that describes a vision in which everyday objects are connected to the Internet, where they are identified and potentially communicate with other devices. These smart objects or smart devices can be defined as real-world artifacts augmented by functions for computing, communicating, sensing, and storing. Their importance lies in their ability to make physical environments smart or to provide novel cyber-physical services to humans. In recent years, several middlewares for smart devices have been proposed.*

1. Which five layers of architecture for IoT have you got to know?

* *Device layer*
* *Network layer*
* *Middleware layer*
* *Application layer*
* *Business layer (Business logic)*

1. What role does the middleware layer play in relation to IoT?

*Middleware, widely used in traditional distributed systems, are fundamental tools for the design and implementation of smart devices as well as smart environment applications. They provide general and specific abstractions (such as object computation models, communication between objects, sensory/actuator interfaces, recognition services, knowledge management) through which smart appliances and their related applications can be built rapidly and easily. Middleware provides standardized interfaces that can be used by different devices in a scalable manner.*

1. Which four requirements of middleware for smart devices did you learn about?
2. *Heterogeneity and application development*
3. *Augmentation variation of smart devices*
4. *Smart device management*
5. *Evolution of smart devices*

**4.5**

1. Which technology can be used to network manufacturing technologies and the IT world? How does this technology work?

*With Open Core Engineering (OCE), possibilities are identified for merging PLC automation and the technologies of the IT world. A PLC is a programmable logic controller, a device that is used to control or regulate a machine or system, and it is programmed on a digital basis. OCE consists of software tools, function packages, open standards, and the “Open Core Interface”. With OCE, manufacturing solutions can be built in a modular manner. This allows rigid manufacturing chains to be split up and replaced. The main focus here is on the efficiency of manufacturing small and tiny quantities (batch size).*

1. How are manufacturing cycles changing and what challenges does this create?

*The industry is in a state of upheaval. The framework conditions for manufacturing companies are changing in all industrial sectors. Product life cycles are becoming shorter and shorter, which means that the quantities being manufactured are also becoming smaller. Hard work is being done to make the machines so flexible that even the smallest volumes can be manufactured economically. As a result, mechanical engineering companies will have to rethink their approach. Manufacturing chains that used to be rigid and expensive must now be modular and cost-efficient. Individual processing stations are being flexibly combined in order to facilitate the manufacture of different products. There is also a need for ways to network the company’s IT systems with the factory floors and the individual machines. These challenges are shifting the core expertise of mechanical engineering companies from classic steel and iron to software developments. Already, a large part of the generated sales of European manufacturing consists of software products.*

1. What is the objective of the Industry 4.0 vision? Explain briefly.

*The target concept of the Industry 4.0 vision is a supply chain that does not require any human interaction, starting with the customer's order, going through production, and ending with delivery to the customer. From a production perspective, the necessary steps have already been taken. In order to be able to manufacture batch sizes of 1 economically, however, the ordered product must also be transferred from the company's IT system into production via secure channels. However, the two worlds are so fundamentally different that this has proven to be a major challenge.*

**Unit 5**

**5.1**

1. Name at least three different types of touchscreens.

* *Wire resistive*
* *Surface capacitive*
* *Projected capacitive*
* *SAW (Surface Acoustic Wave)*
* *Infrared*

1. What types of touchscreens have excellent image sharpness?

* *Projected capacitive*
* *SAW surface monitors (Surface Acoustic Wave)*

1. What is the most widely used touch technology and how does it work?

*Wire resistive touchscreens are the most widely used touch technology today. A resistive touchscreen monitor consists of a glass plate and a film screen. These are each covered with a thin metal layer and separated by a narrow gap. When a user touches the screen, the two metallic layers touch and form a contact. This leads to an electrical flow. The contact point is detected by this voltage change.*

**5.2**

1. Name the four different types of gestures.

* *Symbolic gestures*
* *Indexical gestures*
* *Iconic gestures*
* *Mime gestures*

1. What is meant by symbolic gestures?

*These are gestures that have only one meaning in every culture. A sign, such as the “OK” gesture, is one example, however, American Sign Language gestures also fall into this category.*

1. Fill in the blanks:

Computer-based gesture recognition can be implemented at different *levels of maturity*. Simple systems can identify some *symbolic* gestures. More complex and sophisticated systems can perform *full* *sign interpretations*. Other systems identify *static*, *dynamic,* or *static-dynamic* hand movements. Common to all systems is that each gesture is assigned only one *meaning* at a time.

**5.3**

1. What are the most important features of the human ear?

* *Determination of the pitch of audio signals*
* *the volume and intensity of the sound signal*

1. Describe how a voice control system works.

*For voice control, speech must first be captured and digitized. A voice capture device consists of a microphone and an analog-to-digital converter that digitally encodes the raw speech waveform. To separate speech from non-speech, a special filter is used. Further windowing, scaling, and data compression are also performed. The goal is to enhance and retain only those components of the spectral representation that are useful for recognition purposes, thereby reducing the amount of information that the pattern-matching algorithm must work with. A certain number of these speech parameters in a certain time interval is called a speech frame.*

*This preprocessed speech is cached for the pattern-matching algorithm. This information is compared with speech templates or with generative speech models. The algorithm calculates how well the speech frame matches the templates. A selection with the best results is cached.*

1. What does pattern matching mean when dealing with this subject? Illustrate with an example.

*Pattern matching is used when comparing two speech signals. The speech signal can be shown as the set of numbers that represent certain mnemonic characteristics of the speech. For further processing, a vector is constructed from these numbers by assigning each measured value to a component of the vector. As an example, consider an air conditioning system that measures temperature and relative humidity in an office. If these parameters are measured every minute and the temperature is entered in the first component and the humidity in the second component of a vector, the result is a set of two-dimensional vectors. These vectors describe how the air in the office changes over time. Such vectors are called feature vectors. They can be interpreted in a two-dimensional vector space. Thus, a two-dimensional dependence between humidity and temperature in the office can be drawn. Each measuring point represents a specific time. In the speech signal, multidimensional feature vectors are compared to extrapolate the content.*

**5.4**

1. Which further advances in development can lead to new user interface concepts and input devices?

* *Computer vision*
* *Signal processing*
* *Sensor technology*

1. Which multimodal input concept do you know? Describe it in key points.

*Multi-touch surfaces enhanced with physical tokens narrow the gap between the real and digital worlds.*

1. In the development of multimodal interfaces there is a difference from traditional graphical user interfaces. Describe the challenges in key points.

*Unlike the design of traditional graphical user interfaces, the development of multimodal interfaces involves both software and hardware components. Various development tools provide support for specific interaction modalities, but they are usually limited to a dedicated hardware environment and include other requirements and dependencies.*

**Unit 6**

**6.1**

1. What does ubiquitous computing include?

*Ubiquitous computing (UbiCom) encompasses a wide spectrum of computing devices such as telephones, cameras, game consoles, ATMs, vehicle control systems, cell phones, electronic calculators, household appliances, and computer peripherals such as routers and printers.*

1. What are the features of embedded computer systems?

*The features of embedded (computer) systems are that they are self-contained and perform specific predefined tasks.*

1. How can UbiCom systems be made more useful?

*So that people can use the systems more effectively, the right balance must always be found between the autonomy of the systems and the simultaneous direction of the human operator. It is not currently possible to ensure the operation of more complex systems without people being involved.*

**6.2**

1. Describe a scenario for a ubiquitous computing application.

*Photos or videos are recorded digitally. The recorded content can be instantly shown, shared, or exchanged among friends and family. It can be archived in an external audiovisual (AV) content database. When the AV content is stored, it is tagged with the time and location (the GPS database is used to convert the position to a location context). Image processing can be used to perform face recognition so as to automatically tag all people who can be recognized using the friends and family database. By using micro-electromechanical systems, a previously separate decimeter-sized device, such as a projector, can now be incorporated. The camera is networked and able to detect other specific types of ICT, such as printers, to allow printing to be initiated by the camera. Network access, music, and video player as well as video camera functions could also be combined in this single device.*

1. How has transportation changed in recent years?

*In the 21st-century transportation service, the position of transportation vehicles is determined using automated positioning technology, such as GPS. For each vehicle, the time required to get to specific pickup points, such as the next stop or last stop, is estimated based in part on the current vehicle position, progress, and historical data from other users of the route. Current vehicle arrival times can then be accessed ubiquitously via cell phones or computers, allowing passengers to arrive just in time at passenger and goods receiving points.*

1. How is the food trade of the future going to develop?

*The food trade is being automated using networked physical devices such as refrigerators and other food and beverage storage areas that can take food in and out of storage. Sensors are integrated into the system, for example, to determine the weight of food and of people. Scanners can be used to scan food and beverage packaging for bar codes, text tables, expiration dates, and food ingredients. Hand-held integrated scanners can also select foods, available for purchase in grocery stores, such as supermarkets, which should be avoided for health or personal choice reasons. The system can identify who buys what kind of food in the supermarket.*

**6.3**

1. What are the advantages of context-based omnipresence?

* *limiting the resources needed to provide ubiquitous services, as providing such omnipresent services would be too costly*
* *limiting the choice of access from all possible services to only the useful ones*
* *avoiding overloading the user with too much information and decision-making*

1. Name the three main types of context sensitivity.

* *Context of the physical environment: physical world dimensions or phenomena such as location, time, temperature, precipitation, light level, etc.*
* *Human context (user context or person context): interaction is meaningfully limited by users in terms of identity, preferences, task requirements, social context and other activities, user experience and prior knowledge as well as types of users.*
* *Context of ICT contexts or virtual environments: a particular component in a distributed system is aware of the services that are available in that system, both internally and externally, and locally and remotely.*

1. What is a major problem with context-sensitive systems?

*A major problem with context-sensitive systems is balancing the degree of user control and awareness of their environment. In a (pure) active context-aware system, the UbiCom system is aware of the surrounding context for the user and automatically adapts the system to the context without the user being aware of it. This can be useful in applications where there are strict time constraints, and the user would otherwise not be able to adapt to the context with sufficient speed.*

**6.4**

1. What does autonomy refer to in the context of ubiquitous systems?

*Autonomy refers to the nature of a ubiquitous system in that it is able to control its own actions independently. An autonomous system may still be connected to other systems and environments. However, it controls its own actions. Autonomous systems are defined as systems that are self-determined and can make their own decisions and act independently. Autonomous systems can be goal- or rule-oriented, i.e., they primarily serve to comply with a rule or to achieve a goal.*

1. What constitutes a challenge to autonomy in the context of ubiquitous systems?

*Much of the omnipresent system interaction cannot be fully human-oriented, even if computers become less daunting to interact with. Human interaction can quickly become a bottleneck to the operation of a complex system. Systems cannot always be designed so that there are no humans in the loop.*

1. What example of an autonomous ubiquitous system do you know?

*For example, a printer can estimate the expected time before the printer's toner runs out based on current usage patterns and notify someone to replace the toner.*

**6.5**

1. What is system management all about?

*System management is about gathering information about the operation of a system and making operational and strategic decisions to actively maintain or modify system operations.*

1. What are the three main administrative activities that need to be handled by a smart device management system?

* *Monitoring*
* *Prevention*
* *Correction*

1. In which environments can management systems for smart devices be used?

* *Virtual environments*
* *User-centered environments*
* *Smart environments*

1. What are the requirements for a management system for smart devices in virtual environments (name three)?

* *Primary focus on the management of data processing and the networks*
* *Management of open, dynamic, heterogeneous, volatile services and resources*
* *Management of the various SW and HW functions*
* *Management of various processes between individual distributed devices*
* *Management of communication between different types of smart devices*
* *Management of metadata*