African Virtual University

Applied Computer Science: ITI 1102

EMERGING TECHNOLOGIES

Noela Kipyegen

Foreword

The African Virtual University (AVU) is proud to participate in increasing access to education in African countries through the production of quality learning materials. We are also proud to contribute to global knowledge as our Open Educational Resources are mostly accessed from outside the African continent.

This module was developed as part of a diploma and degree program in Applied Computer Science, in collaboration with 18 African partner institutions from 16 countries. A total of 156 modules were developed or translated to ensure availability in English, French and Portuguese. These modules have also been made available as open education resources (OER) on oer.avu.org.

On behalf of the African Virtual University and our patron, our partner institutions, the African Development Bank, I invite you to use this module in your institution, for your own education, to share it as widely as possible and to participate actively in the AVU communities of practice of your interest. We are committed to be on the frontline of developing and sharing Open Educational Resources.

The African Virtual University (AVU) is a Pan African Intergovernmental Organization established by charter with the mandate of significantly increasing access to quality higher education and training through the innovative use of information communication technologies. A Charter, establishing the AVU as an Intergovernmental Organization, has been signed so far by nineteen (19) African Governments - Kenya, Senegal, Mauritania, Mali, Cote d'Ivoire, Tanzania, Mozambique, Democratic Republic of Congo, Benin, Ghana, Republic of Guinea, Burkina Faso, Niger, South Sudan, Sudan, The Gambia, Guinea-Bissau, Ethiopia and Cape Verde.

The following institutions participated in the Applied Computer Science Program: (1) Université d'Abomey Calavi in Benin; (2) Université de Ougagadougou in Burkina Faso; (3) Université Lumière de Bujumbura in Burundi; (4) Université de Douala in Cameroon; (5) Université de Nouakchott in Mauritania; (6) Université Gaston Berger in Senegal; (7) Université des Sciences, des Techniques et Technologies de Bamako in Mali (8) Ghana Institute of Management and Public Administration; (9) Kwame Nkrumah University of Science and Technology in Ghana; (10) Kenyatta University in Kenya; (11) Egerton University in Kenya; (12) Addis Ababa University in Ethiopia (13) University of Rwanda; (14) University of Dar es Salaam in Tanzania; (15) Universite Abdou Moumouni de Niamey in Niger; (16) Université Cheikh Anta Diop in Senegal; (17) Universidade Pedagógica in Mozambique; and (18) The University of the Gambia in The Gambia.

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Course Overview

Welcome to Emerging Technologies in Applied Computer Science

Emerging technologies are science-based innovations that hold the potential to create a new or improve an existing sector: (Day and Schoemaker(2000) in Rotolo,2016). Therefore, it involves the modern advances and innovations in various fields of technology. The technologies that derived radical innovations include the biotherapy, digital photography, high-temperature superconductors, the micro robots or mobile computing, plus evolving technologies formed by the convergence of the earlier separate areas of research like the magnetic resonance images, electronic banking, high definition TV and the Internet itself. Each of these technologies provide a rich source of market opportunity and the provision of the incentive for bold investments are made. It is in this context that fits this discipline seeking to guide the student to the main lines of research in applied computer science.

To the Instructor/s:

We want to state that emerging technologies are not limited to what we have presented in this script. What we have presented also keep on evolving (emerging); you will find new things concerning the same technologies at the time you will be instructing this module. Our appeal therefore is, do not hesitate to give students current information by updating the notes. You can also introduce another emerging technology of concern at the time of module presentation. In case of the later, make sure to follow the designed module standard of presentation.

Prerequisites

None

The module has no prerequisite. Learners can register for the course in their first year.

Materials

The materials required to complete this course are:

- Computers
- Internet connection
- Recommended books and journals (see below)

Course Objectives

The course aims to provide students with an overview of the trends and future of technology in the area of applied computer science or applied computing with the ultimate goal of nurturing and motivating for innovations, entrepreneurship and business opportunities.

Course Specific Objectives

At the end of this module, students should be able to

- Identify current trends of emerging technologies in the area of applied computer science
- Explain why it is important for Information Technology professionals to keep abreast with the changing technologies
- Discuss the advantages , disadvantages and prospects of some emerging technologies today.
- Demonstrate research skills necessary to identify and evaluate emerging technologies
- Identify the main areas of application of innovative technologies including but not limited to e- Governance, e- Learning, Games

Course Syllabus

- Overview of emerging technologies
- Trends in pervasive and ubiquitous computing
- Convergence of emerging technologies
- Collaborative Research

Units

Unit 0: Pre-Assessment

This is a pre-assessment unit. It tests your knowledge on some of the concepts of emerging technologies.

Unit 1 : Overview of emerging technologies

This unit provides an introduction and context of emerging technologies in general. It defines an emerging technology, gives its characteristics, discusses the general applications of technology, the impacts and sources of emerging technologies which then help the student to quickly grasp subsequent units of this module.

Unit 2 : Pervasive and ubiquitous computing

This unit discusses on the interesting topic of pervasive and ubiquitous computing; what they are, their characteristics, impacts, challenges, applications and technologies involved in pervasive and ubiquitous computing.

Unit 3: Convergence of emerging technologies

This unit will discuss the other emerging technologies which were not mentioned in unit 2 then give the relationship between these technologies; how they converge and the opportunities that come with convergence.

Unit 4 : Collaborative Innovation:

This unit looks at a general overview of innovation, benefits of collaborative innovations to small firms or innovators, challenges that innovators face, collaborations between academia, industry and the governments and last but not least is look at some examples of collaborating firms. This unit will serve as an eye opener to you (student) as an innovator to understand few issues that come with innovations and probably come up with the solutions

Assessment

Formative assessments, used to check learner progress, are included in each unit.

Summative assessments, such as final tests and assignments, are provided at the end of each module and cover knowledge and skills from the entire module.

Summative assessments are administered at the discretion of the institution offering the course. The suggested assessment plan is as follows:

1	Three unit assignment of varying complexity and weights	20%
2	Mid Term exam	10%
3	Final exam	70%

Schedule

Unit	Unit Title	Activities	Estimated time
1	The overview of emerging technologies	Activity 1.1:Definition and characteristics of emerging technologies	8 hours
		Activity 1.2:Impact of emerging technologies on organization and human behaviour	8 hours
		Activity 1.3: Source of emerging technologies	8 hours
2	Pervasive and Ubiquitous computing	Activity 2.1: Overview of pervasive and ubiquitous computing	12 hours
		Activity 2.2: Concerns of ubiquitous computing	8 hours
		Activity 2.3: Technology of pervasive computing	12 hours
3	Convergence of emerging technologies	Activity 3.1: Convergence in the context of emerging technologies	11 hours
		Activity 3.2: Artificial Intelligence	8 hours
		Activity 3.3: Effective computing	9 hours
		Activity 3.4: Cloud computing	8 hours
4	Collaboration and current breakthroughs in ETs	Activity 4.1:Overview of innovations	7 hours
		Activity 4.2: Collaboration between academia, industry and the government	8 hours
		Activity 4.3: Examples of collaborating firms	8 hours
5	Final Exams	Final assessment	2 Hours 3 hours
		TOTAL	120 Hours

Readings and Other Resources

Readings and other features of this course are:

Unit 1: Overview of emerging technologies

- Rotolo D., Hicks D., and Martin B.,(2015). What is an Emerging Technology? Working Paper Series. SWPS 2015-06(February), Version: July 7,2015. Available:www.sussex.ac.uk/spru/research/swps. Distributed under CC-BY-NC-ND. (pg4, 20, 23, 25, 27 &29)
- Veletsianos G, (2010).Emerging Technologies in Distance Education. AU Press (pg 13-17)
- Wenguang Lu, (2011). Study on characteristics of Emerging technologies. IEEE. (pg 1&2)
- Hawala M.(2013). Emerging technology: What is it? Journal of Technology, Management and Innovation. 8(3). (pg110-113).
- World economic forum, (2012). Global Agenda Councils. Emerging Technologies. Available at: (http://reports.weforum.org/global-agenda-council-2012/councils/emerging-technologies/)
- Top 10 emerging technologies of 2015. Available at:http://www.weforum.org/agenda/2015/03/top-10-emerging-technologies-of-2015-2/
- Meghna N. G (2015). Information Technology in Various Fields: Opportunities & Challenges. Available at: (http://www.asmgroup.edu.in/incon/E%20-%20JOURNAL%20INCON%202015/INCON-IT%20Vol2/INCN15_IT_12.pdf).
- Patil, V.M. (2016). INFORMATION TECHNOLOGY AND ITS APPLICATIONS. Available at:https://sites.google.com/site/viveklpm/information-technology-in-veterinary-science/applications-of-information-technology
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- Saha D. and Mukherjee A. (2003). Pervasive computing. A paradigm for 21st century. IEEE computer 36(3): 25-31. Available in : http://intranet.deeei.fct.ualg.pt/IHS/Papers/Mukherjee03.pdf

Unit 2: Pervasive and ubiquitous computing

- Saha D. and Mukherjee A. (2003). Pervasive computing. A paradigm for 21st century. IEEE computer 36(3): 25-31. Available in : http://intranet.deeei.fct.ualg.pt/IHS/Papers/Mukherjee03.pdf

- Saha D. and Mukherjee A. (2011). Networking infrastructure for pervasive computing: Enabling Technologies and Systems. Springer Science & Business Media. (Page1-17)
- Augusto J. C and McCullagh P. (2007). Ambient Intelligence: Concepts and Applications. Int'l J. Computer Science and Information System. 4(1), pp. 1–28.
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- Ehlert, P. A. M. (2003) . Intelligent User Interfaces: Introduction and survey. (Draft version!). Department of Information Technology and Systems Delft University of Technology, The Netherlands. Available at: http://www.kbs.twi.tudelft.nl/docs/report/DKS03-01.pdf

Unit 3: Convergence of emerging technologies

- Rajendra Akerkar (2005). Introduction to AI. Prentice Hall. New Delhi, India
- David Poole and Alan Mackworth (2010). Artificial Intelligence. Foundations of Computational Intelligence. Creative Commons. Canada. Available online:http://artint.info/html/ArtInt_3.html
- John McCarthy (2007). What is Artificial Intelligence? Available:http://www-formal.stanford.edu/jmc/whatisai/whatisai.html
- Papadakis, Stelios (2009) Technological convergence: Opportunities and Challenges, 2-3. Available:https://www.itu.int/osg/spu/youngminds/2007/essays/PapadakisSteliosYM2007.pdf
- Boehner Kirsten, DePaula Rogers, Dourish Paul and Senger Pheobe (2005). Affect: from information. ACM, Newyork.
- Rafael A. C., Sidney D'mello, Jonathan G., Arvid K. (2014). The Oxford Handbook of Affective Computing. illustrated, Oxford University Press
- Hook, Kristina (2014): Affective Computing. In: Soegaard, Mads and Dam, Rikke Friis (eds.). «The Encyclopedia of Human-Computer Interaction, 2nd Ed.». Aarhus, Denmark: The Interaction Design Foundation. Available online at https://www.interaction-design.org/encyclopedia/affective_computing.htm
- Nikos Antonopoulos & Lee Gillam (2010). Cloud Computing: Principles and Networks. (Illustrated) Springer Science & Business Media.
- Kris Jasma (2011). Cloud Computing. SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile Security and more. (illustrated). Jones & Bartlett.
- Rajkumar Buyya, James Brobery & Andrezes M. Goscinski (2010). Cloud computing: Principles and Paradigms. John Wiley & Sons.
- VR, Talsaniya (2015). Cloud Computing- An emerging Technology & Cloud Computing Models.
- R. Buyya, et al., Cloud computing and emerging IT platforms: Vision, hype, and

reality for delivering computing as the 5th utility, Future Generation Computer Systems (2009), doi:10.1016/j.future.2008.12.001

- Rajesh Rege, Cloud Computing: Emerging Trends. CISCO
- Borko Furht & Armando Escalnt (2010). Handbook of Cloud Computing. Computer Science. Springer Science & Business Media.

Unit 4: Collaborative innovations

- Pronk, J, T., Sang, Y. L., Lievense, J., Pierce, J., Palsson, B., Uhlen, M., and Nielsen, J.,(2015). How to set up collaborations between academia and industrial biotech companies. Nature biotechnology. 33(3). pp 237-240. Available at:https://www.docphin.com/research/article-detail/16499952/PubMedID-25748909/How-to-set-up-collaborations-between-academia-and-industrial-biotech-companies
- WEF,(2015). Collaborative Innovation Transforming Business, Driving Growth. World
economic forum. pp 8-19. Available at:http://www3.weforum.org/docs/WEF_Collaborative_Innovation_report_2015.pdf.
- Dodgson,(1994). Technological Collaboration and Innovation. Available at:http://dasta.teipat.gr/system/files/moke/Technological%20Collaboration%20and%20Innovation.pdf
- IBM, (2006). Five barriers to innovations:Key questions and answers. Executive technology report. IBM Global Business Services. Available at:https://www-935.ibm.com/services/uk/igs/pdf/g510-6342-00-5barriers-etr.pdf.
- Pertuze, J. A., Calder, E. S., Greitzer, E. M., and Lucas W. A., (2010). Best Practices for Industry-University Collaboration. MIT Sloam Management Review . pp 84-90. Available at: http://sloanreview.mit.edu/article/best-practices-for-industry-university-collaboration/

Unit 0. Pre-Assessment

Unit Introduction

Dear student,
The purpose of this unit is to check the understanding the level of knowledge you have concerning Emerging Technologies in applied computer science. The exercise should not be worry you at all. It is possible that some or all of you do not have any idea on emerging technologies. This module will cover most the items mentioned on this diagnosis. Now let us start on Emerging Technologies (ETs).

Unit Objectives

Upon completion of this unit you should be able to:

- Describe the contents that make up this discipline.
- Assess the basic knowledge you have on this subject .
- identify key topics that are of interest and focus attention on them as you learn.

Unit Assessment

Check your understanding!

1. Emerging technologies are:
   a. The information and communications technology
   b. The Internet
   c . The mobile telephone
   d. All kinds of technical innovations , representing progress within an area .

2. Examples of emerging technologies include?
   a. Radio broadcasting
   b. 3D Printing
   c . The construction of cars
   d. The desalination of seawater

3. Which of the following are favorable attributes of emerging technologies:
   a. It has possibilities yet unexploited
   b. new and unstable technology
   c . Can create opportunities to / from new markets and new products
   d. Little support (technical and personal) .

4. Cloud computing is a technology that allows :
   a. Putting hard drives in the clouds
   b. Placing servers in the clouds
   c . That users use resources such as software , memory, hard drive, CPU through the Internet without worrying about your location
   d. Multiple computers are networked .

5. Digital TV is :
   a. The transmission and reception of TV signals encoded in digital standard
   b. The television where everything is presented to the viewer in the form of zeros and ones
   c . The satellite TV
   d. The internet satellite.

6. The idea behind biometrics is that each individual is unique and has distinct physiological and behavioral characteristics . The following are physiological characteristics :
   a. Iris
   b. Fingerprint
   c . Voice
   d. Signature.

7. The biometric technologies can be used in a wide range of applications. Name five examples.
   a. Example 1:
   b. Example 2:
   c . Example 3:
   d. Example 4:
   and. Example 5:

8. One of the emerging technologies in computing is ubiquitous computing (ubiquitous), whose characteristics are :
   a. increasing integration of computing devices with our physical world of day-to - day.
   b. greater connectivity
   c . Greater interaction between devices
   d. Mobility.

9. Robotics is a multidisciplinary area , highly active in research development and integration of techniques and algorithms for creating robots . What are the benefits of using robots :
   a. Robots do not receive wages
   b. Do not get sick
   c . They can work 24 hours a day without rest
   d. You not have to go the bathroom in the middle of work.

10. The origin of the term remote sensing is scientifically linked to the development of photography and space research . Two of the four key elements of remote sensing techniques are :
a. actuators
b. Sonsores
c . Telemetry System
d. Triggers.

11. One of the key elements for the operation of a remote sensing system is electromagnetic radiation . What is its importance in this process?
a. Radiation is the only one who can cross the relative emptiness of space
b. heat transfer between the land surface and the atmosphere
c . Transmission of object data to the sensor , as this is the only form of energy that can propagate through a vacuum .
d. The EMN is more comprehensive as a means of propagation.

12. The e- Gov and e-government can be understood as one of the main forms of state modernization and is strongly based on the use of ICT to promote :
a. The efficiency and ease of use of services provided to citizens by the state with support in information and communication technologies;
b. Eliminate the queues at state offices
c . Eliminate direct contact between the public and the state of servers
d. Cutting costs by rationalizing the use of media and state purchases

Instructions

[The above questions include multiple choice , there are questions that have only one correct answer , but some have several possible and correct answers. Carefully read each question and make your choice of the possible answer/s.]

Rating criteria

[Go through the questions, answer them the way you understand then check your answers against the answers you have been given on the table below.]

Question	01	02	03	04	05	06	07	08	09	10	11	12
Answer	d	b, d	a, c	c	a	a, b	book	a, c	all	b, c	a, c	a, d
Mark/s	1	2	2	1	1	2	1	2	2	2	2	2

Unit Readings and Other Resources

The readings in this unit are to be found at the course-level section "Readings and Other Resources".

Unit 1. Overview of emerging technologies

Introduction to Unit

We live in a dynamic world where change is becoming the norm, it is part of our being. You buy a mobile phone today, and in the evening you watch an advert on your TV of a new, super mobile phone, the next day you hear of another modern, better, new technology mobile phone that is available in the market and it continues each day. It happens overnight, each day, hour and minute. The cycle repeats again. What is it? new technology; emerging technologies. This unit will define an emerging technology, give its characteristics, remind you of the general applications of technology, the impacts and the sources of emerging technologies. This will greatly help us understand subsequent units of this module.

Unit Objectives

After completing this unit, you should be able:

- Define and characterize emerging technologies;
- Evaluate the impact of emerging technologies on organizations and society
- Recognize the source of emerging technologies

Key Terms

Information Technology: "refer to anything related to computing technology, such as networking, hardware, software, the internet. Information technology (IT) is the application of computers and telecommunications equipment to store, retrieve, transmit and manipulate data, often in the context of a business or other enterprise" (Meghna,2015): (http://www.asmgroup.edu.in/incon/E%20-%20JOURNAL%20INCON%202015/INCON-IT%20Vol2/INCN15_IT_12.pdf).

Innovation: Innovation is a new idea which, when implemented, leads to a more effective device or process. Innovation can be viewed as the application of better solutions that meet new requirements, unarticulated needs, or existing market needs (https://en.wikipedia.org/wiki/Innovation).

Technology: the application of scientific knowledge for practical purposes, especially in industry (http://www.oxforddictionaries.com).

Emerging Technology: emerging technologies cover a wide range of technologies and are still at the research stage and therefore off the radar of policymakers, but will in time have transformative effects ranging from the emergence of new industries, by disruption of current value chains, to major societal changes in the fields of healthcare and communications (http://reports.weforum.org).

Learning Activities

Activity 1.1 Define and characterize ETs

What are Emerging Technologies (ETs)?

The term 'emerge' according to english dictionary means to become apparent, important, or prominent. On the other hand, technology is used widely in business and science in reference to anything that has the capacity to extend human ability; for example a lighting bulb has the capability to extend human vision. So it is easy to say that technology is a skill set based on a discipline that apply to a particular product or market. Now, what is emerging technology? Business dictionary define emerging technology as "New technologies that are currently developing or will be developed over the next five to ten years, and which will substantially alter the business and social environment. These include information technology, wireless data communication, man-machine communication, on-demand printing, bio-technologies, and advanced robotics".

(http://www.businessdictionary.com/definition/emerging-technologies.html). Rotolo, Heeks and Martin define emerging technology (ET) as a radically novel and relatively fast growing technology characterised by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors,institutions and patterns of interactions among those, along with the associated knowledge production processes. Its most prominent impact however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous (www.sussex.ac.uk/spru/research/swps).

World economic forum report bring out the realization that "They define ETS as;

- Technologies which arise from new knowledge, or the innovative application of existing knowledge
- Those that lead to the rapid development of new capabilities
- Those that are projected to have significant systemic and long-lasting economic, social and political impacts
- Those that create new opportunities for and challenges to addressing global issues
- Technologies that have the potential to disrupt or create entire industries
- Generally, emerging technologies are developed from scientific knowledge and they may alter old processes (or industries) or create a new processes (or industries). Various industries like agriculture, health, manufacturing etc experience large number of emerging technologies (new technologies) that affect their way of doings things.

Examples of emerging technologies include those that were listed by the World Economic Forum's Council in 2015 (http://www.weforum.org/agenda/2015/03/top-10-emerging-technologies-of-2015-2/). These include: fuel cell vehicles, next generation robotics, recyclable thermoset plastics, precise genetic engineering techniques, additive manufacturing, emerging artificial intelligence, distributed manufacturing, 'sense and avoid' drones, neuromorphic technology and digital genome

Also, there are a number of emerging technologies in the area of computing. Examples include: grid, cloud and utility computing; digital TV and IPTV; green IT; RFID; semantic web; crowdsourcing; application mashups; advanced technologies for education; quantum computing; big data; biometrics; augmented reality; e-Business; nanotechnology; voice recognition (speech recognition and voice recognition system) e.t.c

General applications of technology

When a technology emerges, it emerges in (or to) a particular field (domain). That is, its impacts are experienced more in a particular area than another. Thus we want to look at general applications of technology in the area of computing where these technologies can emerge to or from. In much simpler terms, technology is becoming part our daily living. It is applied in most if not all of our daily routines. We find technology in:-

1. **Agriculture**: Food is essential for human sustainability. With the increase in population, climate change among other factors food production has degenerated. Modern and improved ways of increasing food production are enhanced with the use of computer technologies. For example satellite farming, closed ecological systems, agricultural robots e.t.c.
2. **Climate engineering**: We have all experienced the effects of climate change. Most which are man made or caused by human beings. For

example unpredictable seasons, heavy rains being experienced in odd seasons or lack of rains in the expected seasons, too much radiations and other effects. Computing technologies have come in handy in this area to aid in providing solutions or curb this menace. Technologies like green computing, bio-energy, air capture, enhanced weathering among others are being looked at in this field

3. **Construction**: Design and printing are two major activities in our daily activities. Computing technologies come in handy in fulfilling this activity. A simple one include magazine printing; we want to experience the touch. How are we going to achieve this? Think of computing technologies like 3D and Bio-printing technologies. For more information on this read Meghna, 2015, pg100.

4. **Electronics**: This is area that experience immense advancements. Majority of the technologies in this area advance human abilities. Computing is greatly applied in this domain like applications that run the systems (electronic systems). There also excellent technologies that are applicable in this area like biometrics, electronic nose (HCI--sensing ability) among others.

5. **IT and communication:** Communication technology is advancing at an alarming rate. with every development, communication is made affordable, efficient and effective. In this field we are talking of 4G, 5G cellular communication, artificial brain, augmented reality e.t.c. We shall discuss most them later in the module.

6. **Medical**: At a lower level computer technology can be used to maintain patient history and other records or track patience health. Technology can do more than this in health sector. They can be used in advanced diagnosis or treatment, solving complex problems. For example creating artificial uterus, body implants, surgery and many more.

7. **Military**: Computer technology has a great impact in the defence department of any nation. They are used to develop and control various equipment as well as functions in military camps. It also aids communication and coordination of activities. Technologies like plasma weapon, green bullet, laser weapon emerged to this domain. Read more from Meghna, 2015, pg101.

8. **Transport**: movement has been made easy with the introduction of technology. One can easily book a bus, airline etc and every other detail is monitored. Here we can have various technologies emerging to this field like vehicular communication system, electric car, driverless car among so many (Meghna, 2015, pg101)

9. **Education**: Computer technology can be used in teaching and research with the help of the internet. Based on the use of computing in education new techniques and tools are constantly developed to aid in this area like the eLearning tools.

10. **Business and commerce**: Technology has revolutionized business and commerce and now we are talking of global markets. Talk of electronic shopping, electronic banking, virtual online shopping in shopping malls; all these and many more are made possible by computer technology (computing).

11. **Entertainment**: Computing technologies has made easy for people to achieve leisure at their convenience. These achieved by the provision of various options like high powered games, videos, music e.t.c at their comfort. Read more from Patil's website (https://sites.google.com/site/viveklpm/information-technology-in-veterinary-science/applications-of-information-technology).

Characteristics of an emerging technology

Having defined ET a technology which is developing, yet to be understood with the potential to change or impact the society, let us understand its characteristics. These characterics will guide us in the identification of ETs.

1. Uncertainty and ambiguity

Emerging technologies are characterised by high level of unpredictability in their possible end products and applications, which may not turn out as expected or desirable in nature. It may as well be ambiguous depending on the way various groups of users identify with the given technology (www.sussex.ac.uk/spru/research/swps)

2. ETs may or may not be new technologies

The fact that ETs are always perceived as new technologies, this is always not the case. This is because, other technologies emerge as a result of technological convergence of different systems with the same development objectives as a goal. In this context, convergence refers to the previously separate technologies such as voice, data and video, but now share the same resources and mutually interact, greatly increasing efficiency (Valetsianos, 2010).

3. Creative destruction (potentially disruptive)

Emerging technologies have the ability to create new or modify an old industry, altering many other elements like the value chain, the competition rules, the original infrastructure, capacity, thinking model and so on (Lu Wenguang,2011 pg2).

4. Relative fast growth

Unlike non-emerging technologies, ETs show relatively fast growth rates.

5. Coherence and persistence

ETs have attained an identity and momentum. This makes ETs different from other technologies which are still in the state of fluidity (inconsistency).

6. Complex and fuzzy

They are complex simply because their development depend heavily on so many other areas of knowledge. It mostly takes a multidisciplinary approach (Lu Wenguang,2011,pg2)

Other characteristics (by Huang, (2010)) include:

7. The expanding knowledge base

8. The application to the existing markets is undergoing innovation

Conclusion

This activity looked at the definition and characteristics of an emerging technology together with general applications of computing technologies in various fields. We saw ETs as technologies which are under development and bear high degree of uncertainty to the market or industry. They may comprise new or old technologies with the the ability to create a new industry or change an old industry. ETs hold various characteristics that can be used for identification. At the same time, computing technologies are applied to various fields that affect our daily activities like communication, agriculture, transportation, entertainment and many more others.

Activity 1.1 Assessment

1. A technology can be new but not emerging. Discuss (3 marks)
2. Name any three technologies that qualify the definition and characteristics of emerging technologies. (6 marks)
3. Technology can be applied in manufacturing industry. Discuss how it is applied, in waht what industry and identify any ET based on the characteristics that is applied in this area (5 marks)
4. State whether the technologies you named are under new or old categories. (5 marks)

5. In whatever category, (new or old) what qualified it to be an ET. (5 marks)

6. If the technology that you mentioned can create a new market, what kind of market can it create? (4 marks)

Activity 1.2 Impact of emerging technologies on organizations and human behaviour

Introduction

Things are never the same with emerging technologies; not business as usual. We mean, lifestyle change, organizations review their strategies, probably habits and customs too can be affected. Therefore, let us in this activity look at these critical impacts of emerging technologies both to organizations and human behaviour (or social implications).

Impacts of emerging technologies

ETs can have both negative and positive effects on organizations as well as human behaviour. Srinivasan, (2008) discussed three key effects of ETs to organizations. These include:

1. Shifting value chains

Business dictionary define value chain as a set of activities typically consists of (1) inbound distribution or logistics, (2) manufacturing operations, (3) outbound distribution or logistics, (4) marketing and selling, and (5) after-sales service. These activities are supported by (6) purchasing or procurement, (7) research and development, (8) human resource development, (9) and corporate infrastructure (http://www.businessdictionary.com). In this case, the emergence of technology has rendered some of these activities obsolete or some of the activities are bypassed like a manufacturer can sell products directly through the internet rendering the retailers (middlemen) jobless, for example.

2. Digitization of goods

This has revolutionize how information is generated, accessed, cost and availability (e.g. in time and place). For example movies that are accessed on 'pay-per-view'.

3. Shifting locus of innovation to outside the firm

One of the characteristics of ETS is that they emerge from various disciplines (multidisciplinary). This means that they are developed across various industries. They may also emerge as a result of convergence of technology from various firms or industries. These and many more like innovation outsourcing (Srinivasan, 2008) led to shift in the locus of innovation to outside the firm.

Other impacts of emerging technologies include the ones mentioned in world economic forum report as discussed below; (http://reports.weforum.org/global-agenda-council-2012/councils/emerging-technologies/).

1. Informatics for Adding Value to Information Innovations in how information is organized, mined and processed help minimize or filter the amount of noise generated on daily basis and hence the use the growing wealth of global information to address emerging challenges.
2. Synthetic Biology and Metabolic Engineering This has led to the development of new biological processes and organisms that are designed to serve specific purposes. For example, conversion of biomass to chemicals, fuels and materials, production of new therapeutic drugs or protection of the body against harm.
3. Green Revolution 2.0 – Technologies for Increased Food and Biomass Integration of knowledge (innovations) between the biological and physical sciences, has enabled the new green revolution. This revolution has the promises high farm yields, reduced effects on the environment, reduced energy and water dependence, among others.
4. Nanoscale Design of Materials "The high demand on natural resources requires revolutionary gains in efficiency. Nanostructured materials with tailored properties, designed and engineered at the molecular scale are already showing novel and unique features that will usher in the next clean energy revolution, reduce our dependence on depleting natural resources, and increase atom-efficiency manufacturing and processing" http://reports.weforum.org/global-agenda-council-2012/councils/emerging-technologies/.
5. Systems Biology and Computational Modeling/ Simulation of Chemical and Biological Systems Systems biology and computational modelling and simulation are playing increasingly important roles in designing therapeutics, materials and processes that are highly efficient in achieving their design objectives, while reducing its possible impacts on human health and the environment. This technologies improve on healthcare and bio-based manufacturing.
6. Using Carbon Dioxide as a Resource Carbon is at the heart of all life on earth. Yet, managing carbon dioxide releases is one of the greatest social, political and economic challenges of our time. An emerging innovative approach to carbon dioxide management involves transforming it from a liability to a resource. Novel catalysts, based on nanostructured materials, can potentially transform carbon dioxide to high value hydrocarbons and other carbon-containing molecules. These could be used as new building blocks for the chemical industry as cleaner and more sustainable alternatives to petrochemicals.

7. Wireless Power Society is deeply reliant on electrically-powered devices. Yet, a significant limitation in their continued development and use is the need to be attached to the electricity grid by wire – either permanently or through frequent battery recharging. Emerging approaches to wireless power transmission will free electrical devices from being physically plugged in, and are poised to have as significant an impact on personal electronics as Wi-Fi had on Internet use.

8. High Energy Density Power Systems. Better batteries are essential if the next generation of clean energy technologies are to be realized. A number of emerging technologies are coming together to lay the foundation for advanced electrical energy storage and use, including the development of nanostructured electrodes, solid electrolysis, and rapid-power delivery from novel supercapacitors based on carbon-based nanomaterials. These technologies will provide the energy density and power needed to supercharge the next generation of clean energy technologies.

9. Personalized Medicine, Nutrition and Disease Prevention. As the global population exceeds 7 billion people – all hoping for a long and healthy life – conventional approaches to ensuring good health are becoming less and less tenable, spurred on by growing demands, dwindling resources and increasing costs. Advances in areas such as genomics, proteomics and metabolomics are now opening up the possibility of tailoring medicine nutrition and disease prevention to the individual. Together with emerging technologies like synthetic biology and nanotechnology, they are laying the foundation for a revolution in healthcare and well-being that will be less resource intensive and more targeted to individual needs.

10. Enhanced Education Technology. ETs come with new methods that can be applied in education especially alleviating challenges related to the growing population and education hence creating a knowledge economy. This has been made possible by the internet or "hyperconnected globalized society". Read more on this from http://reports.weforum.org/global-agenda-council-2012/councils/emerging-technologies/.

Conclusion

ETs have a number of impacts which can be desirable or undesirable to the society and organizations. Organizations need to leverage on these impacts in order to remain relevant and competitive. At the same time the society need to keep pace with these technologies in order to improve their well-being and decision making.

Activity 1.2 Assessment

1. Identify one emerging technology in your institution (2 marks)
2. How is it applied (list its applications). (2 marks)
3. Assess its impacts in the context of application and to the entire institution (3 marks)
4. Identify and discuss two other positive and negative impacts of ETs to an organization and the society. Qualify your identification using examples and/or illustrations. (5 marks)

Activity 1.3 Source of emerging technologies

Where do emerging technologies come from?

Emerging technologies are designed and developed in small, dedicated labs in institutions of research or de novo firms explicitly set up to develop the new technologies (Srinivasan, 2008-pp 634). These small de novo firms may be called living labs. According to Nyström and Leminen (2011), "the use of Living Labs has emerged as a novel form of creating value, competences and competitive advantage. Living Labs can be defined as functional regions where stakeholders have formed a partnership of firms, public agencies, universities, institutes and users, which consequently collaborate in the creation, prototyping, validating and testing of new services, products and systems in real-life contexts. Such contexts include cities, villages, rural areas, industrial plants as well as public places such as airports. The living lab model draws from open innovation approach".

At its infancy stage, the technology's benefits are not feasible to the field of application or the area that the technology is 'emerging to' as mentioned previously in activity 1.1. The technology therefore, goes through a cycle of enhancement or 'evolution' from low performing to high performing technology. As it evolves, its benefits 'costs' become visible.

Often than not, organizations that feel threatened by the emergence start to engage in the development of the technology. Sooner, the technology develops into an application production.

The cooperation between the small labs or de novo firms with large organizations who leverage the emerging technology is seen as a 'relay race' which is seen as an important concept in innovations (Srinivasan, 2008-pg 634). Read more on this from Srinivasan, R. (2008-pp 634-635) and Nyström and Leminen (2011 -pg1-4).

Conclusion

This activity looked at the sources of emerging technologies. It was clearly made known that emerging technologies originate from small labs or firms that are dedicated to research in various fields. These technologies are later picked-up by other interested firms leading to cooperation between originating firms, organizations, users (consumers) as well as other research firms.

Activity 1.3 Assessment

1. Nyström and Leminen (2011) said that living labs are drawn from open innovation approach. Research on open innovation approach then take short notes on describing open innovation.
   (5 marks)
2. Do you think your institution has a living lab or a lab that produces innovations. If so, what is the name of the lab and what does it specialize in? who are its key stakeholders? partners? what has it designed?
   (5 marks)
3. Find out how a living lab is designed or developed.
   (5 marks)
4. Identify any other living lab or firm that is dedicated to innovations in computing. What are some of their achievements? and what do they specialize in? (5 marks)
5. If you were to ask your department to start a living lab.
   What area of specialization would you prefer and why?
   (5 marks)
6. In your answer above (5) who do you think will be your major stakeholders or partners? and what type of living lab will you be designing (based on Nyström and Leminen (2011)-types of living labs)
   (5 marks)

Unit Summary

This unit defined ETs as technologies which are under development and bear high degree of uncertainty to the market or industry. They may comprise new or old technologies with the the ability to create a new industry or change an old industry. ETs hold various characteristics that can be used for identification. At the same time, computing technologies are applied to various fields that affect our daily activities like communication, agriculture, transportation, entertainment and many more others. ETs have a number of impacts which can be desirable or undesirable to the society and organizations. Organizations need to leverage on these

impacts in order to remain relevant and competitive. At the same time the society need to keep pace with these technologies in order to improve their well-being and decision making. Technologies emerge from various sources which include small labs or firms that are dedicated to research in various fields. These technologies are later picked-up by other interested firms leading to cooperation between originating firms, organizations, users (consumers) as well as other research firms.

Unit assessment

1. Define the following:

   i. Emerging technology (2 marks)

   ii. living lab (2marks)

2. Emerging technologies are i.) potentially disruptive ii.) uncertain and ambiguous. Discuss.
   (5 marks)

3. Open innovation approach is considered the best approach when developing technologies. Briefly discuss the concept of open innovation approach in relation to innovation development
   (5 marks)

4. Discuss any five impacts of emerging technologies to organizations and society (5 marks)

Grading Scheme

This assessment has been allocated marks

Feedback

Solutions

1. i.) ETs as technologies which are under development and bear high degree of uncertainty to the market or industry. They may comprise new or old technologies with the the ability to create a new industry or change an old industry.

   Ii.) Living lab is a user-centred, open-innovation ecosystem, often operating in a territorial context (e.g. city, agglomeration, and region), integrating concurrent research and innovation processes within a public-private-people partnership.

2. i.) Potentially disruptive: Emerging technologies have the ability to create new or modify an old industry, altering many other elements like the value chain, the competition rules, the original infrastructure, capacity, thinking model and so on

   ii.) uncertain and ambiguous Emerging technologies are characterised by high level of unpredictability in their possible end products and applications, which may not turn out as expected or desirable in nature. It may as well be ambiguous depending on the way various groups of users identify with the given technology

3. The concept is based on a systematic user co-creation approach integrating research and innovation processes. These are integrated through the co-creation, exploration, experimentation and evaluation of innovative ideas, scenarios, concepts and related technological arteifacts in real life use cases. Such use cases involve user communities, not only as observed subjects but also as a source of creation. This approach allows all involved stakeholders to concurrently consider both the global performance of a product or service and its potential adoption by users……..student can expand

4. Student can discuss: Fast growth rate, coherence, complex, expanding knowledge base, potentially disruptive, uncertain and ambiguous

Course Readings and other resources

Readings and other features of this course are:

- Rotolo D., Hicks D., and Martin B.,(2015). What is an Emerging Technology? Working Paper Series. SWPS 2015-06(February), Version: July 7,2015. Available:www.sussex.ac.uk/spru/research/swps. Distributed under CC-BY-NC-ND. (pg4, 20, 23, 25, 27 &29)
- Veletsianos G, (2010).Emerging Technologies in Distance Education. AU Press (pg 13-17)
- Wenguang Lu, (2011). Study on characteristics of Emerging technologies. IEEE. (pg 1&2)
- Hawala M.(2013). Emerging technology: What is it? Journal of Technology, Management and Innovation. 8(3). (pg110-113).
- World economic forum, (2012). Global Agenda Councils. Emerging Technologies. Available at: (http://reports.weforum.org/global-agenda-council-2012/councils/emerging-technologies/)
- Top 10 emerging technologies of 2015. Available at:http://www.weforum.org/agenda/2015/03/top-10-emerging-technologies-of-2015-2/
- Meghna N. G (2015). Information Technology in Various Fields: Opportunities & Challenges. Available at: (http://www.asmgroup.edu.in/incon/E%20-%20JOURNAL%20INCON%202015/INCON-IT%20Vol2/INCN15_IT_12.pdf).
- Patil, V.M. (2016). INFORMATION TECHNOLOGY AND ITS APPLICATIONS. Available at:https://sites.google.com/site/viveklpm/information-technology-in-veterinary-science/applications-of-information-technology
- SRINIVASAN, R. (2008). Sources, Characteristics and Effects of Emerging Technologies: Research Opportunities in Innovation. Industrial Marketing Management, Vol 37, 633-640.
- Nyström, A. and Leminen, S. (2011). Living Lab - A New Form of Business Network. Proceedings of the 2011 17th International Conference on Concurrent Enterprising (ICE 2011). IEEE pg 1-10.

Unit 2. Pervasive and Ubiquitous Computing

Unit Introduction

Technology is all around us; in our living rooms, bathrooms, kitchen, our arms (watches), probably our cloths name them. The most intrinsic thing about these technologies is how they can communicate with one another and adapt to the users' environment (your environment). Think about it! How can technology be 'anywhere any time'. How can two or more devices learn of each other in a particular environment? Let us take a tour of this interesting topic of pervasive and ubiquitous computing; know what they are, their characteristics, impacts, challenges, applications and technologies involved in pervasive and ubiquitous computing.

Unit Objectives

Upon completion of this unit you should be able to:

- Characterize the ubiquitous computing.
- Identify the applications of ubiquitous computing;
- Describe the concerns of ubiquitous computing
- Recognize the technologies involved in pervasive and ubiquitous computing

Key Terms

Ubiquitous Computing (ubicomp): is a concept in software engineering and computer science where computing is made to appear anytime and everywhere. In contrast to desktop computing, ubiquitous computing can occur using any device, in any location, and in any format.

Pervasive computing: also known as ubiquitous computing (ubicomp) is a concept in software engineering and computer science where computing is made to appear everywhere and anywhere.

Ubiquitous network: is a federation of networks on which user-oriented services are provided anywhere and anytime to a target user in the most appropriate way with null operational cost. Ubiquitous network allows all users to access and exchange information of any kind freely at anytime, from anywhere, and from any appliance through the use of broadband and mobile access as well as intelligent home appliances and RFID tags that can access networks (Trivedi, Sagar and Vernon, 2010)

Radio Frequency Identification (RFID): is a technology that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to uniquely identify an object, animal, or person (http://internetofthingsagenda.techtarget.com).

Computing: is any goal-oriented activity requiring, benefiting from, or creating algorithmic processes—e.g. through computers. Computing includes designing, developing and building hardware and software systems; processing, structuring, and managing various kinds of information; doing scientific research on and with computers; making computer systems behave intelligently; and creating and using communications and entertainment media (https://en.wikipedia.org/wiki/Computing).

Learning Activities

Activity 2.1 Overview of pervasive and ubiquitous computing

Introduction

Computing technology can be described in three levels or generations which portray a bigger picture computing trends. The first era of computing employed mainframe computers. These were huge computers. This era can be characterized by limited computers in the world. The second era of computing apply used desktop computers. The era is marked by unlimited number of computers in the world with the ability of interconnections (to the internet). The third era is the era of ubiquitous computing where computers are everywhere, anytime with very high interconnectivity capability. They are more smaller than second era computers, see figure 2.1 on the trends of computing. As the size decreased so is the increase in the number of computers in the world. They are found everywhere, virtually almost in any object, not only on the desk.

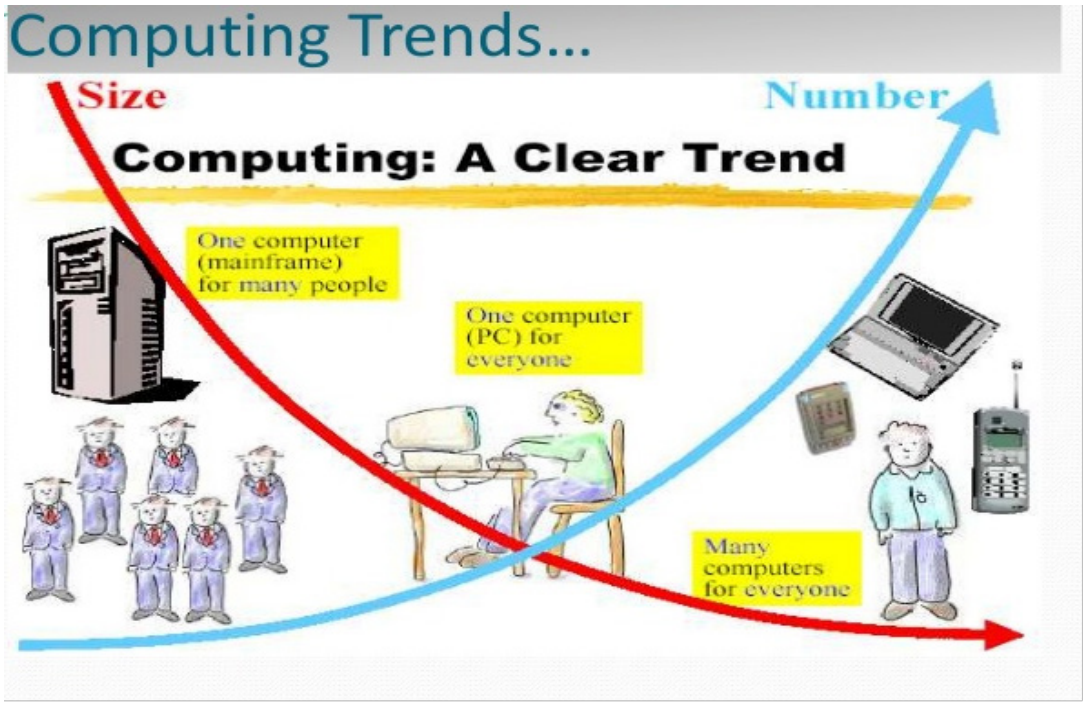

Figure 2.1 Trends of computing. source: govind raj (2013)

Now, what is pervasive and ubiquitous computing?

Pervasive and ubiquitous computing

"Ubiquitous Computing is the study of improving the interaction between users and computers. It is basically a model of Human Computer Interaction (HCI) where we focus on finding ways how the interaction between human and computer can be simplified; here we mainly focus on computer being an integral part of human life such that we are unaware of their presence"

Ranga, (2015).

Pervasive computing is also called "ubiquitous computing, calm technology, things that think, everywhere, pervasive internet, ambient intelligence, proactive computing and/or augmented reality". It is the trend towards increasingly ubiquitous connected computing devices in the environment (Singh, 2010). This means, the more the computers are embedded into devices the more they become ubiquitous with the help of ubiquitous network. This trend is brought about by convergence of various technologies like the advanced electronics supporting wireless technologies and the Internet. Pervasive computing include very tiny, mostly invisible devices that are either mobile or embedded in virtually every usable object by human beings, including buildings, cookers, cars, clothing, appliances among other consumer goods. These devices communicate via interconnected networks. Therefore, unlike desktop computing, ubicomp can occur using any device, in any location and in any format. Humans interact with ubicomp in various ways including laptop computers, tablets and terminals in everyday objects.

The word pervasive means to be embedded or build in other objects, see figure 2.2 on pervasive computing. While ubiquitous stand for "ever present or omnipresent".

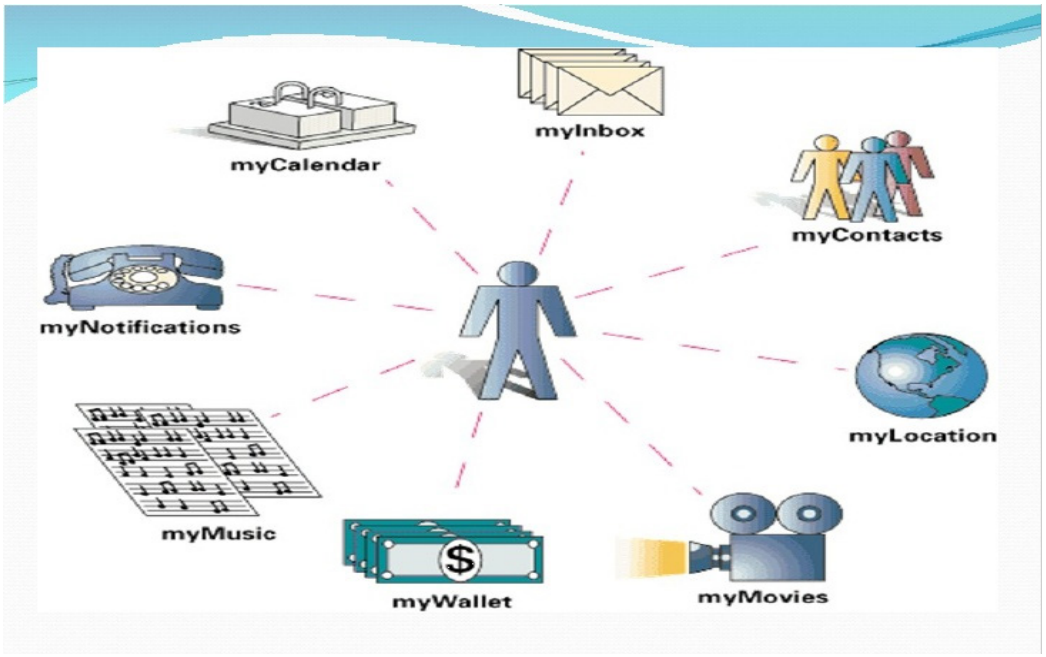

Figure 2.2 Pervasive computing.source: VijayaLakshmi N. (2012)

Mark Weiser, the father of pervasive and ubiquitous computing had conceived the idea that the most profound technologies are those that disappear and weave themselves into the fabric of everyday life until they are indistinguishable from it. It means that these technologies adapt to the environment and form part of human's life without interference. Some authors like Ranga, (2015) have defined these technologies as "calm technologies" simply because they recede to the background of most if not all human's daily life. Ubiquitous computing allows large scale integration of mobility with pervasive computing functionality-see figure 2.3.

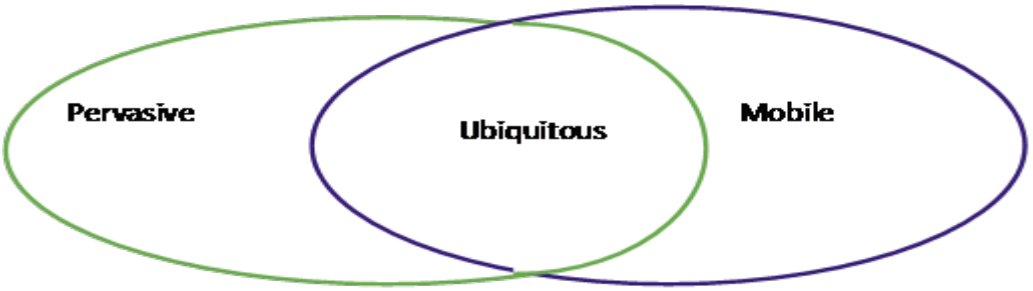

Figure 2.3 Enabled mobility with pervasive computing

Ubicomp is influenced by a number of fields in computer science and software engineering like mobile computing, human computer interaction (HCI), location computing, distributed computing, mobile networking, context-aware computing, sensor networks, artificial intelligence, physical computing, Internet of Things and haptic computing.

History of ubiquitous computing (and evolution)

According to Ranga, (2015), the history of ubicomp can be traced back to early 1940's until now. In early 1940s, Vanavar Bush developed an idea which later translated to the computers, hypertext and the internet. In the modern world, the internet is a critical tool which has revolutionized human behaviour. In 1950/60s Douglas Engelbart was engaged in the development of things like hypertext and computer mouse extending Vanavar's idea. Douglas's idea was how technology can be used to support people in their collective tasks. In 1970s Alan Kay recognized the impact of technology it were universally available and the fact that ubiquitous computing solely depends on knowing that knowledge is fluid and evolving where computers can come in handy to support student construction of knowledge through a myriad of media. Another researcher, Seymour Papert in 1980s developed an urge for ubiquitous computing in education, for example, application of technology in education.

Mark Weisa at around 1988 during his tenure as Chief Technologist of the Xerox Palo Alto Research Centre (PARC) did a ground breaking work in the area of ubicomp and was the first to define it as it is now. This is the very reason many authors call him the founder and father of ubicomp. Weiser wrote some of the earliest papers on the subject, largely defining it and sketching out its major concerns. Weiser recognized that the extension of processing power into everyday scenarios would necessitate understandings of social, cultural and psychological phenomena beyond its proper ambit; Weiser was influenced by many fields outside computer science, including Philosophy, phenomenology, anthropology, psychology, post-modernism, sociology of science and feminist criticism. He was explicit about «the humanistic origins of the 'invisible ideal in post-modernist thought'".

Later, Andy Hopper from Cambridge University UK proposed and demonstrated the concept of «Teleporting»; where applications follow the user wherever they move. Roy Want, who was a researcher and student working under Andy Hopper at Cambridge University, worked on the «Active Badge System», which is an advanced location computing system where personal mobility is merged with computing.

Bill Schilit (now at Google) also did some earlier work in this topic, and participated in the early Mobile Computing workshop held in Santa Cruz in 1996. University of Tokyo, Japan developed a Ubiquitous Networking Laboratory (UNL) under Dr. Sakamura's and together with the T-Engine Forum, jointly works together with the goal of enabling any everyday device to broadcast and receive information. MIT has also contributed immensely through research in this field, notably Things That Think consortium (directed by Hiroshi Ishii, Joseph A. Paradiso and Rosalind Picard) at the Media Lab and the CSAIL effort known as Project Oxygen. Other major contributors include University of Washington's Ubicomp Lab (directed by Shwetak Patel),Georgia Tech's College of Computing, Cornel University's People Aware Computing Lab, NYU's Interactive Telecommunications program, UC Irvine's Department of informatics, Microsoft Research, Intel Research and Equator, Ajou University UCRi & CUS.

Now, where are we? It is research and more research where more technologies emerge. Also ubicomp is made real by joint efforts of the researchers.

Evolution of pervasive computing

Pervasive computing defines a major evolutionary step in work that began in the mid 1970s. As seen earlier, steps towards pervasive computing include;

- Distributed systems and
- Mobile computing.
- Other areas that influenced pervasive computing are:
- Sensor networks
- Human computer interaction
- Artificial intelligence

You are required to read more on evolution from http://www.slideshare.net/anshumanbiswal/pervasive-computing-41310241 (page 9-11) and Saha and Mukherjee (2003) – see reference for the link.

The core concept of ubicomp

At their core, all models of ubiquitous computing share a vision of small, inexpensive, robust networked processing devices, distributed at all scales throughout everyday life and generally turned to distinctly commonplace ends. For example, a domestic ubiquitous computing environment might interconnect lighting and environmental controls with personal biometric monitors woven into clothing so that illumination and heating conditions in a room might be modulated, continuously and imperceptibly. Another common scenario posits refrigerators «aware» of their suitably tagged contents, able to both plan a variety of menus from the food actually on hand, and warn users of stale or spoiled food.

Ubiquitous computing presents challenges across computer science: in systems design and engineering, in systems modelling, and in user interface design. Contemporary human-computer interaction models, whether command-line, menu-driven, or GUI-based, are inappropriate and inadequate to the ubiquitous case. This suggests that the «natural» interaction paradigm appropriate to a fully robust ubiquitous computing is yet to emerge - although there is also recognition in the field that in many ways we are already living in a ubicomp world. Read more on Natural User Interface (NUI) inhttp://en.wikipedia.org to understand human-machine interface for invisible devices; see also figure 2.4 and 2.5 on natural user interface (Microsoft research). Contemporary devices that lend some support to this latter idea include mobile phones, digital audio players, radio-frequency identification tags, GPS and interactive whiteboards.

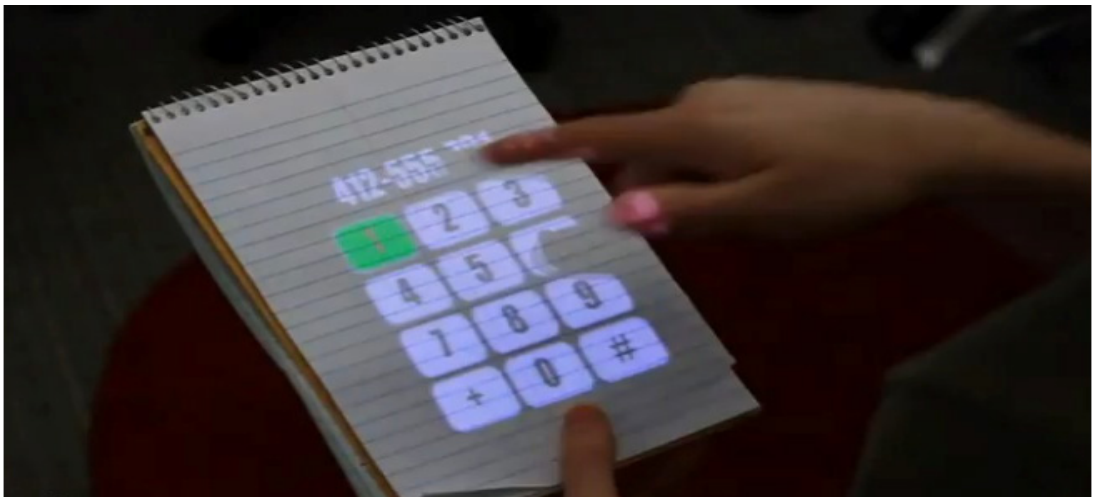

Figure 2.4 NTU. Source:https://blog.notebooksbilliger.de/microsoft-stellt-natural-user-interface-vor/

Figure 2.5 NTU. Source: (Microsoft perspective)

Read more on this in http://mscorp.indsyntest.com/perspective/articles/innovation/ushering-in-the-futuristic-natural-user-interface.html to understand how NUI will revolutionize computing industry, making technology more ubiquitous and easy to use.

Mark Weiser proposed three basic forms for ubiquitous system devices:

- Tabs: wearable centimetre sized devices
- Pads: hand-held decimetre-sized devices
- Boards: metre sized interactive display devices.

Read more in https://en.wikipedia.org/wiki/Smart_devise to understand these basic forms for ubicom based on smart devices

These three forms proposed by Weiser are characterized by being macro-sized, having a planar form and on incorporating visual output displays. If we relax each of these three characteristics we can expand this range into a much more diverse and potentially more useful range of Ubiquitous Computing devices. Hence, three additional forms for ubiquitous systems have been proposed. These are:

Dust: miniaturized devices can be without visual output displays, e.g. Micro Electro-Mechanical Systems (MEMS), ranging from nanometres through micrometers to millimetres. Read more onsmart dust from https://en.wikipedia.org/wiki/Smartdust and/orwww.slideshare.net/khushbookapoor/smartdust. See figure 2.5 on smart dust components.

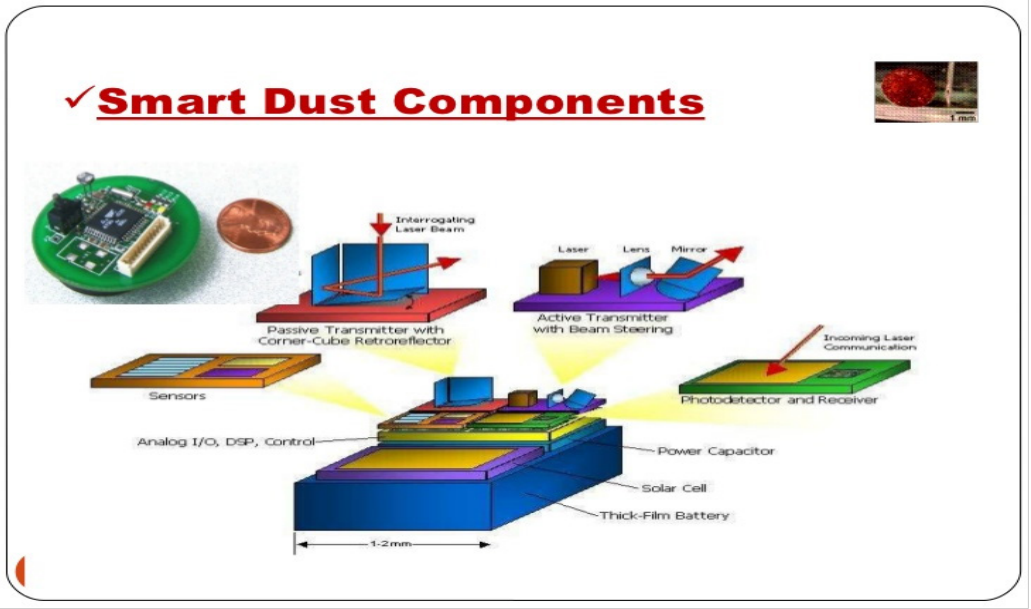

Figure 2.6 Smart Dust Components. Source: Khushboo Kapoor (http://www.slideshare.net/)

2. Skin: fabrics based upon light emitting and conductive polymers, organic computer devices, can be formed into more flexible non-planar display surfaces and products such as clothes and curtains. To learn more readhttps://en.wikipedia.org/wiki/OLED on OLED display. For example those that are developed by Samsung, see figure 2.7 showing LG display. MEMS device can also be painted onto various surfaces so that a variety of physical world structures can act as networked surfaces of MEMS.

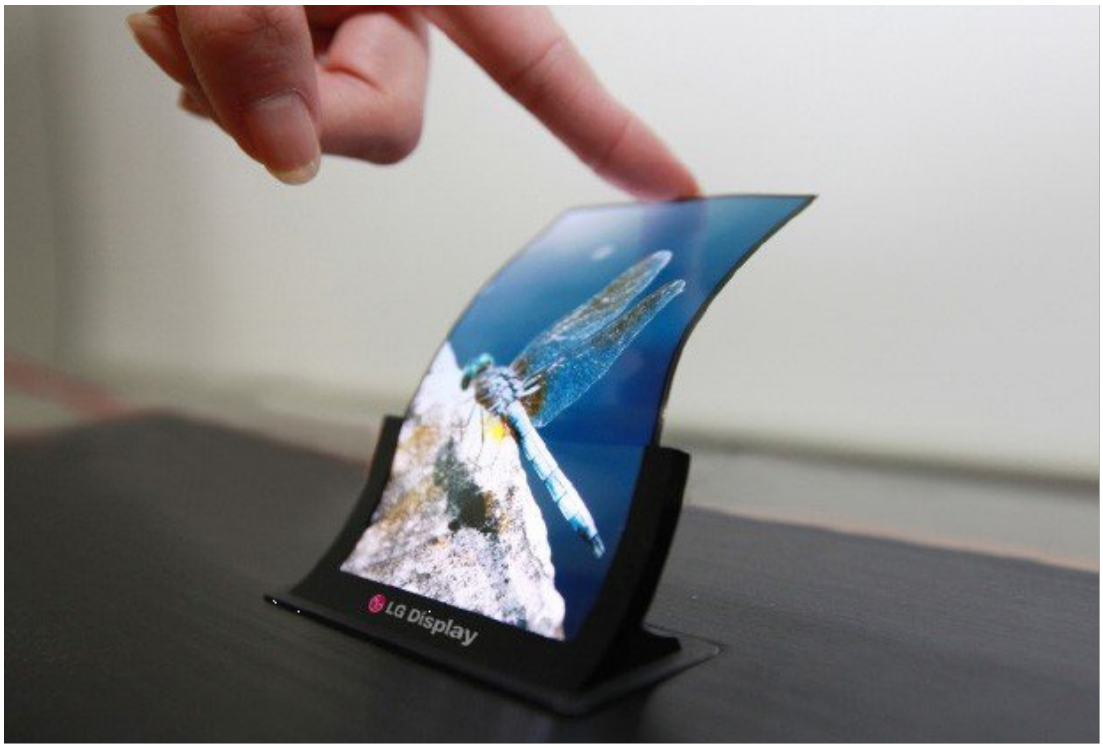

Figure 2.7 OLED Display source:http://news.oled-display.net/flexible-curved-oled/

3. Clay: ensembles of MEMS can be formed into arbitrary three dimensional shapes as artefacts resembling many different kinds of physical object, see figure 2.8 on TUI. Read on Tangible User Interfaces (TUI) by Ishii (2006), page 1-5 which is available at www.cs.tufts.edu/~jacob/workshop/papers/ishii.pdf and/or from https://en.wikipedia.org/wiki/Tangible_user_interface

Figure 2.8 tangible interfaces.Source: en.wikipedia.org

Manuel Castells in his book, "The Rise of the Network Society", suggests that there is an ongoing shift from already-decentralized, stand-alone microcomputers and mainframes towards entirely pervasive computing. In his model of a pervasive computing system, Castells uses the example of the Internet as the start of a pervasive computing system. The logical progression from that paradigm is a system where that networking logic becomes applicable in every realm of daily activity, in every location and every context. Castells envisages a system where billions of miniature, ubiquitous inter-communication devices will be spread worldwide, «like pigment in the wall paint».

Just to summarize on the core of ubicomp, we can say that ubicomp or pervasive computing has four major principles which include:

- **Decentralization**: it is the ability use the applications on mobile devices and synchronize updates with network based systems
- **Diversification**: because of their size, ubicomp devices are tailored to a specific type of information which target a specific need
- **Connectivity**: this enables synchronization and exchange of information between devices. It applies wireless connections and the internet.
- **Simplicity**: it is the ability to provide seamless interface that target specific needs of the user where complex technology is hidden behind user friendly user-interface. Interfaces like speech recognition, touch screens and many others.

Characteristics of ubiquitous technology

The characteristics of ubicomp by Muller (2006) and Ranga(2015) include:

1. **Miniaturisation**: the core idea is reducing the size of devices to allow ease of mobility by humans at the same time achieve the idea of invisibility
2. **Embedding**: ubicomp devices are embedded into other components or objects.
3. **Networking**: they rely on connectivity for ease of communication. The connection occurs at the time of use and ceases when not in use.
4. **Ubiquity**: This describe ubicomp technology as a situation in which the users are surrounded by various embedded systems which are mostly invisible and weaved into the background of the surrounding, like appliances and they communicate via a network or are interconnected
5. **Context awareness:** ubicomp technologies are able to capture the information about the environment of their operations and react appropriately. Example of context includes time and location. In other words, they capture the context, assign meaning and change behaviour accordingly. This attribute aid in personalization of services.

6. **Limited power**: because of their size ubicomp technologies consume less power. One small cell is able to run the device for a number of years or throughout its lifespan.

Read more on these characteristics in Ranga, (2015) page 1412-1413. Available in ieeexplore.ieee.org

Conclusion

Pervasive computing technologies are tiny, embedded, networked, context aware and with limited power devices. They must disappear to the background with the capability of supporting users without noticing. The step towards pervasive computing started with distributed systems, mobile computing, sensor networks, human computer interaction and artificial intelligence. Natural (Natural User Interface-NUI) paradigm is considered appropriate for development of ubicomp technologies

Activity 2.1 Assessment

1. What do you understand by the word natural user interface? (2 marks)
2. Ubicomp has many characteristics including context aware and limited power. Explain these two characterics.
   (4 marks)
3. Briefly describe distributed system, mobile computing, sensor networks, human computer interactions and artificial intelligence in relation to ubicomp (20 marks)
4. Discuss four major principles of ubicomp
   (8 marks)
5. Research on:

   Internet of things then write a one page summary (include definition, characteristics, applications and examples). Present this work to your instructor (20 marks)

Activity 2.2 Concerns of ubiquitous computing

Introduction

Ubicomp is a technology that is anywhere, anytime (as seen in activity 2.1). Therefore it can be anticipated to have immense influence on human behaviour or socio-economic context both in a negative and positive way. Our concerns in this activity are: what are some of the impacts of ubicom? what are some of the challenges of ubicom? and what are the applications of ubicomp?

Impacts of pervasive computing (or ubicomp)

Pervasive computing can impact various areas of human life including:

- Privacy
- Economic
- Social

Read more fromwww.bsi.bund.de/SharedDocs/Downloads/DE/BSI/Publikationen/Studien/Percenta/Percenta_eacc_pdf.pdf?_blob=publicationFile (page 13-15)

Challenges of ubicomp

Impediments are inevitable in any advancement. These impediments must be conquered in order to achieve the desired breakthrough. In order for ubicomp to succeed, they must disappear to the background. As we saw earlier, the main aim of ubicomp is to design invisible devices that users can easily apply without noticing. Therefore, in order to succeed, ubicomp has to conquer the following challenges

1. The "Accidentally" Smart Environment

"If you walk into an environment anywhere in the world, you would probably not find an infrastructure suitable for ubiquitous computing devices. Instead, you would find an infrastructure suited towards established and well-grounded technologies, such as electricity running through the walls, phone lines running into and out of buildings, and conveniences such as indoor plumbing. You are not likely to see newly constructed buildings equipped with devices to support pervasive computing" Trivedi, Sagar and Vernon,(2010).

2. Impromptu interoperability

Majority of technology-producing companies wish to create their own proprietary products using their domain vocabularies "or language". This generates non interoperability between devices from different companies, inhibiting the growth of ubiquitous computing.

3. No system administrator

There is lack of user support on how to apply or use the complex interwoven "interconnected" ubicomp.

4. Social implications of aware technologies

Ubicom leads to information streaming to and from the device. The challenge is the too much input. How will a user filter the input? What is the effect of this on privacy? how will the society react to this? will they seek legal or ethical solutions or technological solution to protect privacy? This is the biggest challenge which destroys user's technological trust.

5. Reliability

Due to its nature "still emerging", ubicomp has not attained the required reliability level. It is still unstable and developing unlike other technologies like television.

Read more on ubicom challenges from (Trivedi, Sagar and Vernon,2010- page 73-74)-see unit reference for the link.

Applications of ubicomp

Ubicomp are applied in various areas like;

1. Smart phones
2. Health care
3. Smart homes
4. Intelligent transportation systems
5. Interactive wall papers
6. Identification systems
7. Smart badges
8. Goggle glasses
9. Ubiquitous city
10. Security

Read more fromwww.bsi.bund.de/SharedDocs/Downloads/DE/BSI/Publikationen/Studien/Percenta/Percenta_eacc_pdf.pdf?_blob=publicationFile (page 13-15)

Conclusion

Ubicomp impact on various areas of human life which include privacy, economic and social context. It also faces myriad of challenges which include The "Accidentally" Smart Environment, impromptu interoperability, no system administrator, social implications of aware technologies and reliability. At the same time its applications are so many including identification systems, smart homes, health care among others. Therefore even with its challenges ubicomp technology has attained some degree of acceptance and seen as a potential technology in all aspects.

Activity 2.2 Assessment

1. Discuss the impacts of ubicomp on privacy, economic and social life (6 marks)
2. Ubicomp creates "accidentally" smart environment. Discuss (3 marks)
3. How is ubicomp applied in smart homes and identification systems? (10 marks)
4. Research on:

   The impacts of pervasive computing technologies in education, create a summary and present to your instructor
   (10 marks)

Activity 2.3 Technology of pervasive computing

Introduction

To achieve its goal (ubiquity), which entail the development of tiny, invisible, cheaper, faster, more energy efficient with bigger storage but small in size devices, various enabling technologies must be applied. These technologies amalgamate knowledge from different domain areas. This activity will take us through pervasive computing model with the involved technologies.

Pervasive (Ubicomp) computing model

Ubicomp model constitutes four technological advances which aid in the creation of pervasive computing environment. The four areas are:

1. Devices

Ubicomp environment need to contain a certain degree of intelligence. Therefore components like, the traditional input devices (mice, keyboards), output devices (speakers or light emitting diodes), wireless mobile devices (pagers, personal digital assistant, cell phones, palmtops etc), smart devices like intelligent appliances, floor tiles with embedded sensors and biosensors are crucial and can be applied. This is to mean, pervasive computing should encompass every device worldwide that has built-in active and passive intelligence. Objects are augmented with a digital presence while maintaining their original look, goal and use.

2. Pervasive networking

Networking technology will aid pervasive technologies to proliferate. With this, the number of pervasive devices will be expected to surpass the estimated worldwide population of people. Hopefully, in the next few coming years, there will be more than 300 million PDAs, more than two billion consumer electronic devices like wireless phones, pagers, and settop boxes, and more than five billion everyday devices like vending machines, refrigerators, washing machines and many others with integrated chips and connected to a pervasive network. The major enable is the internet which is expected to completely integrate pervasive computing devices into the existing social system. As a result of proliferation most of the current technologies need to be refurbished.

3. Pervasive middleware

Middleware also known as the shell is critical element in the development of pervasive computing as it enables the interface between networking kernel and the end user applications running on pervasive devices. The pervasive middleware will mediate interactions with the networking kernel on the user's behalf and will keep users immersed in the pervasive computing space. See figure 2.9on pervasive computing framework. Middleware must mask heterogeneity to make pervasive computing invisible to user Saha and Mukherjee(2003).

4. Pervasive applications

Applications will guide the middleware and networking issues to a great extent simply because pervasive computing is more environment centric. An example is a heart monitor device implanted to a patient and communicating wirelessly. It may be required to communicate any abnormalities based on the knowledge about its context. Therefore, an application is critical in this case.

You are required to read more on ubicomp model. Refer to Saha and Mukherjee(2003). Acessit fromhttp://intranet.deeei.fct.ualg.pt/IHS/Papers/Mukherjee03.pdf (page 26-28) or the book by Saha and Mukherjee.(2011) -page 7-16.

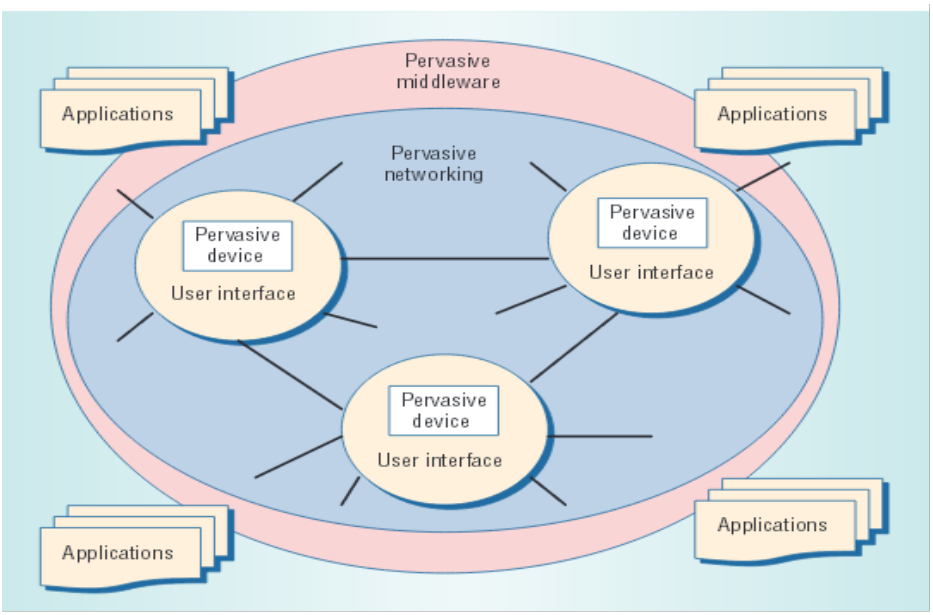

Figure 2.9 Pervasive computing framework source: Saha & Mukherjee (2003)

Fundamental technologies for building a pervasive technology include ambient intelligence, ubiquitous communication (which we have come across severally in previous and this activity) and intelligent user interface see figure 2.10 on these key technologies

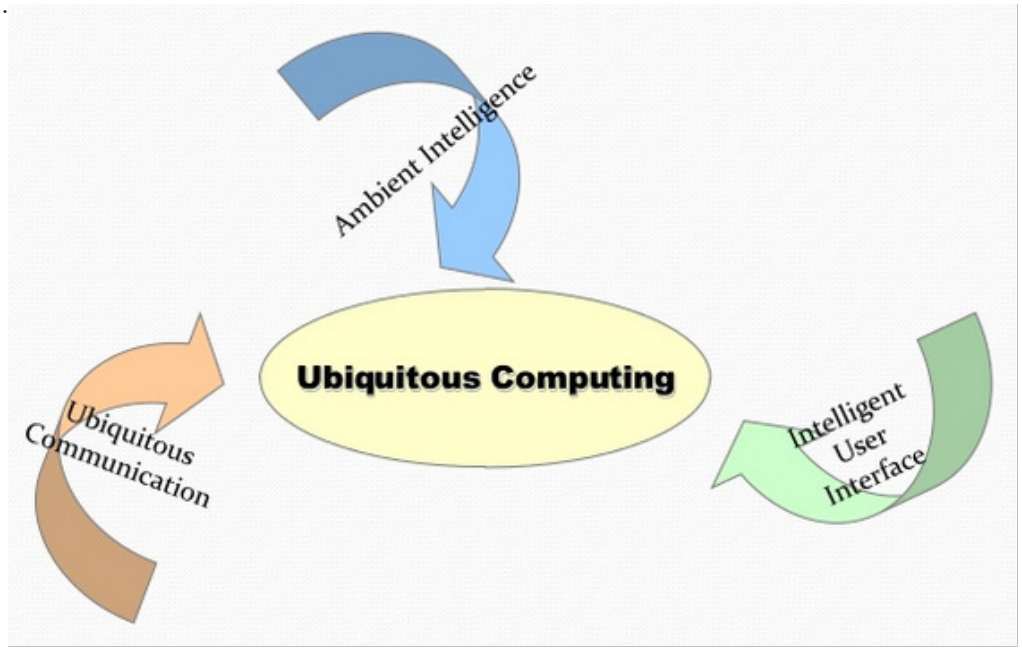

Figure 2.10 Ubicomp technologies source:Raj (2013)

Ambient intelligence

Ambient intelligence (AmI) refers to electronic environments that are sensitive and responsive tothe presence of people. Ambient intelligence is a technology targeting consumer electronics, telecommunications and computing that was originally developed in the late 1990s for the time frame 2010–2020. In an ambient intelligence world, devices work in concert to support people in carrying out their everyday life activities, tasks and rituals in an easy, natural way using information and intelligence that is hidden in the network connecting these devices. To understand this better read on Internat of Things which is the application of Aml (fromhttps://en.wikipedia.org/wiki/Internet_of_Things). As these devices grow smaller, more connected and more integrated into our environment, the technology disappears into our surroundings until only the user interface remains perceivable by users.

Aml paradigm builds upon pervasive computing, ubiquitous computing, profiling, context awareness and human-centric computer interaction design and is characterized by systems and technologies that are:

- Embedded: many networked devices are integrated into the environment
- Context aware these devices can recognize you and your situational context
- Personalized: they can be tailored to your needs
- Adaptive: they can change in response to you
- Anticipatory: they can anticipate your desires without conscious mediation.

Ambient intelligence is closely related to the long term vision of an intelligent service system in which technologies are able to automate a platform embedding the required devices for powering context aware, personalized, adaptive and anticipatory services.

Where in other media environment the interface is clearly distinct, in an ubiquitous environment 'content' differs. Such a smart environment can be described as ambient media. It is constituted of the communication of information in ubiquitous and pervasive environments. The concept of ambient media relates to ambient media form, ambient media content, and ambient media technology. Its principles include manifestation, morphing, intelligence, and experience.

In order for AmI to become a reality a number of key technologies are required:

- Unobtrusive hardware (Miniaturization, Nanotechnology, smart devices, sensors etc.)
- Seamless mobile/fixed communication and computing infrastructure (interoperability, wired and wireless networks,service-oriented architecture, semantic web etc)
- Dynamic and massively distributed device networks, which are easy to control and program (e.g. service discovery, auto-configuration, end-user programmable devices and systems etc.)
- Human-centric computer interfaces (intelligent agents, multimodal interaction, context awareness etc)
- Dependable and secure systems and devices (self-testing and self repairing software, privacy ensuring technology etc.)

The following characteristics will permit the societal acceptance of ambient intelligence:

- AmI should facilitate human contact.
- AmI should be oriented towards community and cultural enhancement.
- AmI should help to build knowledge and skills for work, better quality of work, citizenship and consumer choice.
- AmI should inspire trust and confidence.
- AmI should be consistent with long term sustainability - personal, societal and environmental - and with lifelong learning.
- AmI should be made easy to live with and controllable by ordinary people.

Aml technologies

Technologies (see figure 2.11) that can be used to enable Ambient intelligence environments are:

- Bluetooth low energy
- RFID
- ICT implant
- Sensors
- Software agents

- Affective computing
- Nanotechnology
- Biometrics

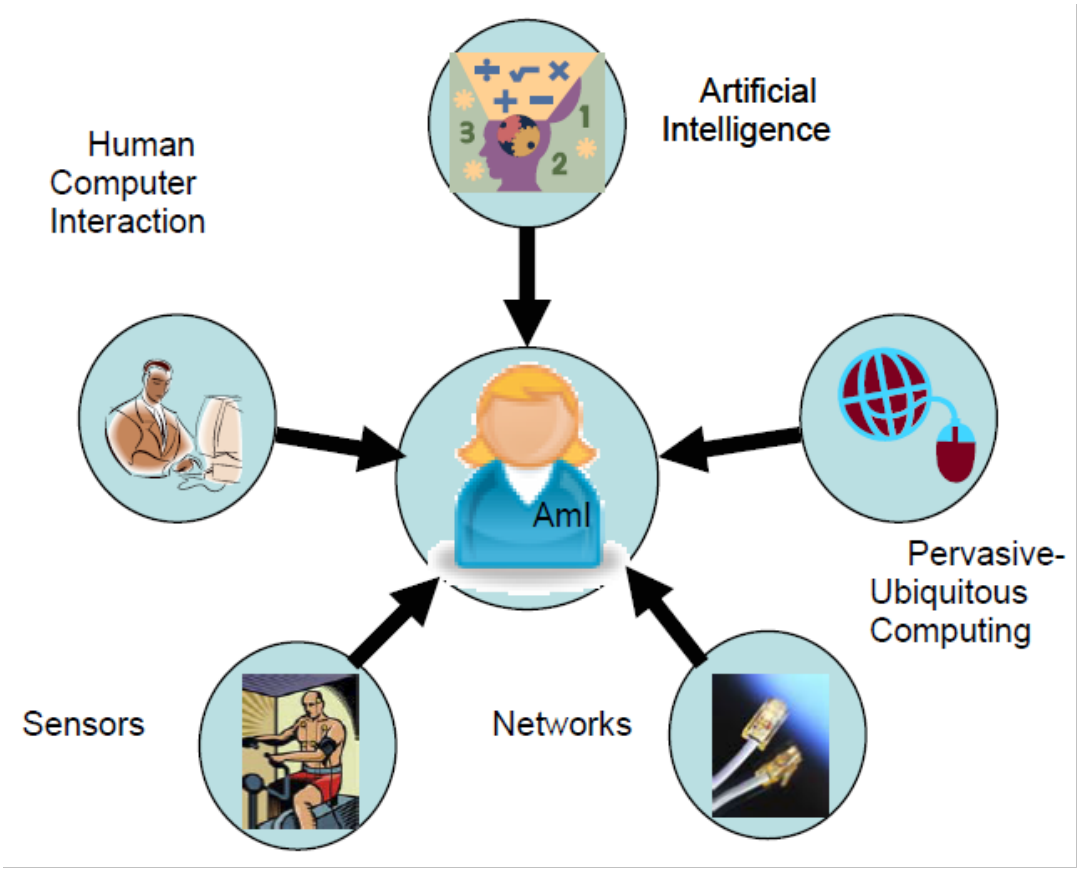

Figure 2.11 Relation between AmI and other areas in computer science source: Augusto and McCullagh (2007)

Applications of AmI

AmI can be applied in various environments (read Augusto and McCullagh (2007) and/or Cook, Augusto, and Jakkula, (2009). pp 277–298 - see reference) including:

- Smart homes
- Health related applications
- Public transportation sector
- Education services
- Emergency services
- Production oriented places
- Public surveillance
- Ubiquitous communication

"Ubiquitous communication means enabling, anywhere, anytime the communication of anything with anything else not only between people but also between objects of which the

computing is part. This include ad hoc networking and wireless communication such as low-power short range networks" Mihailidis and Bardram (2006).

A wireless ad hoc network (WANET) is a decentralized type of wireless network. The network is ad hoc because it does not rely on a pre existing infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Instead, each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity. In addition to the classic routing, ad hoc networks can use flooding for forwarding data. Wireless mobile ad hoc networks are self-configuring, dynamic networks in which nodes are free to move. Wireless networks lack the complexities of infrastructure setup and administration, enabling devices to create and join networks «on the fly» – anywhere, anytime

Ad hoc network is a network without any base stations "infrastructure-less" or multi-hop. it is a collection of two or more devices equipped with wireless communications and networking capability that supports anytime and anywhere computing. It is supported by two topologies: Heterogeneous (differences in capabilities) and homogeneous or fully symmetric (all nodes have identical capabilities and responsibilities) Mishra & Awerbuch (2008. The ad hoc network on the left is heterogeneous while homogeneous on the right (see figure 2.12).

Read more on ad hoc networking from http://www.cs.jhu.edu/~cs647/intro_adhoc.pdf

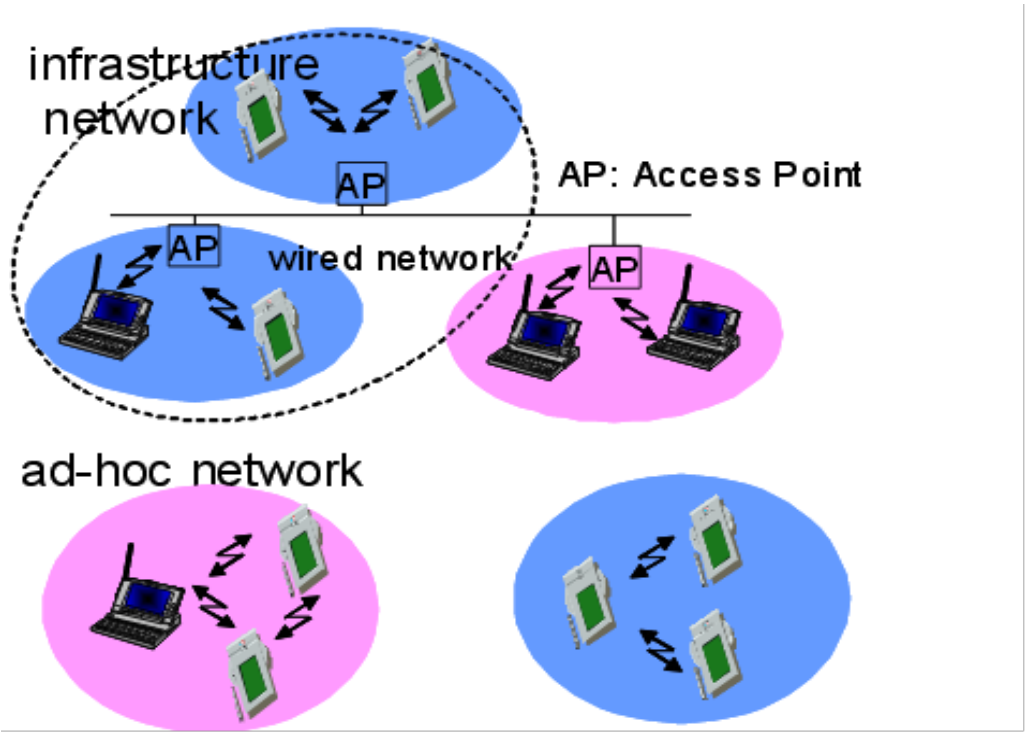

Figure 2.12 Ad hoc networks source: Mishra &Awerbuch 2008

Applications of ad hoc network

The decentralized nature of wireless ad-hoc networks makes them suitable for a variety of applications where central nodes can't be relied on and may improve the scalability of networks compared to wireless managed networks, though theoretical and practical limits to the overall capacity of such networks have been identified. Minimal configuration and quick deployment make ad hoc networks suitable for emergency situations like natural disasters or military conflicts. The presence of dynamic and adaptive routing protocols enables ad hoc networks to be formed quickly. Wireless ad-hoc networks can be further classified by their application:

Mobile ad hoc networks (MANETs)

A mobile ad hoc network (MANET) is a continuously self-configuring, infrastructure-less network of mobile devices connected without wires.

Vehicular ad hoc networks (VANETs)

VANETs are used for communication between vehicles and roadside equipment. Intelligent vehicular ad hoc networks (InVANETs) are a kind of artificial intelligence that helps vehicles to behave in intelligent manners during vehicle-to-vehicle collisions, accidents.

Smartphone ad hoc networks (SPANs)

SPANs leverage the existing hardware (primarily Bluetooth and Wi-Fi) in commercially available smartphones to create peer-to-peer networks without relying on cellular carrier networks, wireless access points, or traditional network infrastructure.

Internet-based mobile ad hoc networks (iMANETs)

iMANETs are ad hoc networks that link mobile nodes and fixed Internet-gateway nodes. One implementation of this is Persistent System's CloudRelay.

Millitary/Tactical MANETs

Military/Tactical MANETs are used by military units with emphasis on security, range, and integration with existing systems.A mobile ad-hoc network (MANET) is an ad-hoc network but an ad-hoc network is not necessarily a MANET

Other short range wireless networks

A number of different wireless technologies have been developed for very short distances. These are referred to as 'short-range wireless communication.' Signals travel from a few centimeters to several meters. Examples of short-range wireless communications are Bluetooth, infrared, near field communication, ultraband and Zigbee. Read more on short range wireless network fromhttp://

study.com/academy/lesson/short-range-wireless-communication-bluetooth-zigbee-infrared-transmission.html andhttp://www.slideshare.net/zaripices/comparison-of-short-range-wireless-networks-pan-s

Intelligent user interface

Intelligent user interfaces(IUIs) form a subfield of Human-Computer Interaction (HCI) research. The main aim of IUIs is to enhance HCI by use of smart technologies. This interaction is not limited to a computer, but can also be applied to improve the interface of other computerized machines, for example the television, refrigerator, or mobile phone. Using techniques from artificial intelligence, IUIs deal with different forms of input and output and try to help the user in an intelligent fashion. They try to solve some of the problems that the current direct manipulation interfaces cannot, such as (Ehlert, 2003) :

1. Creation of personalized systems
2. Information overflow or filtering problems
3. Providing help on using new and complex programs
4. Taking over tasks from the user
5. Other forms of interaction

Properties of IUI (according to Ehlert, 2003)

The most important property of IUIs is that they are designed to improve communication between the user and machine. It does not matter much what kind of technique is used to achieve this improvement, as long as it can be regarded as .intelligent.. Below we give a list of several types of techniques that are being used today in intelligent user interfaces:

- Intelligent input technology uses innovative techniques to get input from a user. These techniques include natural language, gesture tracking and recognition, facial expression recognition, and gaze tracking among others;
- User modeling covers techniques that allow a system to maintain or infer knowledge about a user based on the received input;
- User adaptivity includes all techniques that allow the communication between human and machine to be adapted to different users and different situations for example, machine learning or context awareness;
- Explanation generation covers all techniques that allow a system to explain its results to a user for example, speech output, intelligent interface agents, tactile feedback in a virtual reality environment.
- Besides improved communication, other important properties of IUIs are personalization and flexibility of use. To achieve personalization, IUIs often include a representation of a user. These user models log data about the user's

behavior, knowledge, and abilities. New knowledge about the user can be inferred based on the input and interaction history of the user with the system. In order to be flexible many IUIs use adaptation or learning. Adaptation can occur based on the stored knowledge in a user model or by making new inferences using current input. Learning occurs when stored knowledge is changed to reflect new data. Because of the difficulties involved in creating IUIs and the amount of knowledge engineering that is needed, most IUIs focus on a specific method of interaction (e.g. speech) or on a particular well-defined application domain.

Read (Ehlert, 2003). Available at: http://www.kbs.twi.tudelft.nl/docs/report/DKS03-01.pdf

Conclusion

Devices, pervasive networking, pervasive middleware, and pervasive applications are technical advances necessary for creation of pervasive computing environment. Where as fundamental areas that come together during the development of ubicomp include ambient intelligence, ubiquitous communication and intelligent user interface. Technologies (see figure 30) that can be used to enable Ambient intelligence environments are: bluetooth low energy, RFID, ICT implant, sensors, software agents, affective computing, nanotechnology and biometrics

Activity 2.3 Assessment

1. You are required to read on bluetooth low energy, RFID, ICT implant, sensors, software agents, affective computing, nanotechnology and biometrics. Then briefly state what they are giving a real example of where they have been applied (existing device or systems that applies these technologies).
   (40 marks)

Unit Summary

Computing has come along way from the mainframe era to desktop era to pervasive computing which is marked by large number of computers in the world that are smaller in size. Pervasive computing is also known as ubiquitous computing. The aim of ubicomp is to create devices that disappear to the user's background. These devices need to have high degree of intelligence. Distributed systems together with mobile computing technologies served as stepping stones towards computer ubiquity. Various technologies in engineering, computer science and software engineering greatly influence the emergence and proliferation of ubicomp. These include sensor technology, biometrics, RFID, artificial intelligence, human computer interaction, networking among others. These means ubicomp is as a result of technology convergence. As much as ubicomp technology being accepted in the world, it also has issues that need to be addressed for it to gain high level acceptance. With the proliferation

of this technology, it is expected that there will be millions to billions of smart, intelligent system in the word which will supersede human population. Therefore, ubicomp will continue to emerge and be the technology to be watched in the coming years.

Unit assessment

1. Describe the trends in computing.
(5 marks)

2. Define the following (8 marks)

   i. pervasive computing

   ii. pervasive communication

   iii. RFID

   iv. Natural user interface

2. List

   i. Three key fundamental technologies of ubiquitous computing.

   (3 marks)

   ii. Four ubicomp application areas (4 marks)

3. What do you think are the effects of ubicomp on distance learning?
(5 marks)

4. Differentiate between zigbee and bluetooth
(4 marks)

5. Name two applications of each of the following
(10 marks)

   i. Sensors

   ii. Software agents

   iii. Affective computing

   iv. Nanotechnology and

   v. Biometrics

6. Ubicomp entail a model that constitutes four technologies. Name these technologies (4 marks)

7. Pervasive computing was influenced by distributed systems and mobile computing. Explain
(4 marks)

8. Some of the challenges of ubicomp include impromptu interoperability and lack of system administrator. Explain why they perceived as challenges (4 marks)

9. Ubicomp devices must disappear to the background. Discuss (3 marks)

10. Describe four core principles of ubicomp (8 marks)

11. Create a scenario of your own of a technology or system that can be used to give a solution in your country (it can be community, learning institution, agriculture, health or an organization among others) that applies ubicomp core principles with the aid of enabling technologies. (10 marks)

Grading scheme

Each activity has been allocated marks. Compute cumulative marks for all the activities in unit 2 then convert to 5%

Feedback

1. The first era of computing employed mainframe computers. These were huge computers. This era can be characterized by limited computers in the world. The second era of computing apply desktop computers. The era is marked by unlimited number of computers in the world with the ability of interconnections (to the internet). The third era is the era of ubiquitous computing where computers are everywhere, anytime with very high interconnectivity capability. They are more smaller than second era computers. As the size decreased so is the increase in the number of computers in the world. They are found everywhere, virtually almost in any object, not only on the desk.

2. i. Pervasive computing: is the growing trend towards embedding microprocessors in everyday objects so they can communicate information. The words pervasive and ubiquitous mean «existing everywhere.» Pervasive computing devices are completely connected and constantly available.

   ii. Pervasive communication: is an interaction that occurs through the environment of its participants, i.e. the devices with processing and communication capacity available in this environment

iii. RFID: is the use of radio waves to read and capture information stored on a tag attached to an object. A tag can be read from up to several feet away and does not need to be within direct line-of-sight of the reader to be tracked.

iv. Natural user interface:is a user interface that is effectively invisible, and remains invisible as the user continuously learns increasingly complex interactions.

3. i. ambient intelligence, ubiquitous communication (which we have come across severally in previous and this activity) and intelligent user

ii. Smart phones, Health care, Smart homes, Intelligent transportation systems, Interactive wallpapers, Identification systems, Smart badges, Goggle glasses, Ubiquitous city, Security

4. -Real time data for research

- anytime anywhere knowledge

- any other relevant answer from the student

5. Zigbee is an open global standard for wireless technology designed to use low-power digital radio signals for personal area networks. ZigBee operates on the IEEE 802.15.4 specification and is used to create networks that require a low data transfer rate, energy efficiency and secure networking whereas bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices, and building personal area networks (PANs)

6. i. Sensors: Industry, safety and security, industrial process control, measurement and automation, Aircraft, Medical products, Automobiles, Consumer electronics etc.

ii. Software agents: Buyer agents or shopping bots, User or personal agents, Monitoring-and-surveillance agents, Data-mining agents etc

iii. Affective computing: e-learning applications, Robotic systems, social monitoring, development of communicative technologies for use by people with autism etc

iv. Nanotechnology: everyday material and processes, electronics and IT applications, sustainable energy, environmental remediation, nanobiosystems/medical/health applications , transportation etc

v. Biometrics: access control, time and attendance management, surveillance etc

7. Devices, pervasive networking, pervasive middleware, application

8. Student to discuss relationship between distributed systems and mobile computing with pervasive computing

9. Impromptu interoperability

Majority of technology-producing companies wish to create their own proprietary products using their domain vocabularies "or language". This generates non interoperability between devices from different companies, inhibiting the growth of ubiquitous computing.

No system administrator

There is lack of user support on how to apply or use the complex interwoven "interconnected" ubicomp.

10. They must be embedded (student to expand..)

11. **Decentralization**: it is the ability use the applications on mobile devices and synchronize updates with network based systems

Diversification: because of their size, ubicomp devices are tailored to a specific type of information which target a specific need

Connectivity: this enables synchronization and exchange of information between devices. It applies wireless connections and the internet.

Simplicity: it is the ability to provide seamless interface that target specific needs of the user where complex technology is hidden behind user friendly user-interface. Interfaces like speech recognition, touch screens and many others.

12. Instructor to score based on relevance

Unit Readings and Other Resources

The readings in this unit are to be found at course level readings and other resources.

- Saha D. and Mukherjee A. (2003). Pervasive computing. A paradigm for 21st century. IEEE computer 36(3): 25-31. Available in : http://intranet.deeei.fct.ualg.pt/IHS/Papers/Mukherjee03.pdf
- Saha D. and Mukherjee A. (2011). Networking infrastructure for pervasive computing: Enabling Technologies and Systems. Springer Science & Business Media. (Page1-17)
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- Cook, D.J, Augusto, J. C and Jakkula, V. R (2009). Ambient intelligence: Technologies, applications, and opportunities. Pervasive Mob. Comput. 5(4), 277–298
- Mishra, A. and Awerbuch, B. (2008). Introduction to Ad-hoc Networks. CS-647: Advanced Topics in Wireless Networks, Department of Computer Science, John Hupkins University. Available at: http://www.cs.jhu.edu/~cs647/intro_adhoc.pdf
- Ehlert, P. A. M. (2003) . Intelligent User Interfaces: Introduction and survey. (Draft version!). Department of Information Technology and Systems Delft University of Technology, The Netherlands. Available at: http://www.kbs.twi.tudelft.nl/docs/report/DKS03-01.pdf

Unit 3. Convergence of the Emerging Technologies

Unit Introduction

In the previous unit we looked at a number of emerging technologies and their applications. Here, we shall mention a few other technologies that are deemed to be emerging, then understand the relationship between these technologies (convergence).

Unit Objectives

Upon completion of this unit you should be able to:

- Explain what convergence is in context to emerging technologies.
- Discuss the relationship between various emerging technologies
- Predict the technologies that would emerge

Key Terms

Convergence: is defined as a process by which telecommunications, information technology and media, sectors that originally operate largely independent of one another are growing together (Papadakis, 2009) OR it is the tendency for different technological systems to evolve towards performing similar tasks (Wikipedia)

AI: is the intelligence exhibited by machines or software. It is also the name of the academic field of study which studies how to create computers and computer software that are capable of intelligent behavior (https://en.wikipedia.org/wiki/Artificial_intelligence).

Affective computing: is the study and development of systems and devices that can recognize, interpret, process, and simulate human affects. It is an interdisciplinary field spanning computer science, psychology and cognitive science (https://en.wikipedia.org/wiki/Affective_computing).

Cloud computing: also known as on-demand computing, is a kind of Internet-based computing that provides shared processing resources and data to computers and other devices on-demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources. Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centres (https://en.wikipedia.org/wiki/Cloud_computing)

Learning Activities

Activity 3.1 - what is convergence in context to emerging technologies

Introduction

As we saw earlier, technologies are always evolving at a much faster rate. One thing to be noted about these technologies is that they move towards achieving similar goal. Technology A combines with technology B to achieve more strength in meeting objective C. Thus we are talking about the relationship between different technologies and how they blend together in pursuance of meeting a target. In unit 2 (activity 2.1) we learnt that the blend led to the emergence of the concept of ubiquity in computing. What else can be achieved from the convergence of technology? For example,figure 3.1 below shows few technologies before convergence and how they relate after convergence.

Activity Details

In this activity, you are required to research more on the opportunities of technological convergence. Check the reference section for this unit for reading materials. At the end of this activity, you will be required to present a summary of the opportunities that come with technological convergence

Conclusion

This activity involved the understanding and the ability to define technological convergence. This will greatly help you (the student) to quickly learn the relationship between different technologies and how they combine with the aim of achieving a particular task. This, takes us to other technologies and their relationship with previously mentioned technologies; see unit 1 and 2.

Activity Assessment

1. What is technological convergence? (2 marks)
2. Why is it important to learn this concept of technological convergence? (3 marks)
3. Discuss any four opportunities that come with technological convergence (8 marks)
4. Briefly explain technology before convergence and after convergence (5 marks)

Activity 3.2 - Artificial intelligence

Introduction

Artificial Intelligence

Artificial Intelligence (AI) refers to an Artificially constructed intelligence rather than to one which has developed naturally without the need for human intervention outside the normal biological process of procreation. This involves a simulation of natural intelligence which naturally occurs in living things using a computer. John McCarthy define AI as the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, though AI does not have to confine itself to methods that are biologically observable. The word intelligence has different meaning to different people. According to David Poole and Alan Mackworth, intelligence can be characterized as the ability to perform appropriate task or action for intended circumstances and achieve its goals, flexibly change according to changing environments and goals, learn from experience, and make appropriate choices given perceptual and computational limitations. From these characteristics, Rajendra Akerkar lists the tasks that demand intelligence and these include; speech generation and understanding, pattern recognition, motion in dynamic obstacle filled space, mathematical theorem proving and reasoning. In short, AI involves three steps; perception, cognition and action, see figure 3.2;

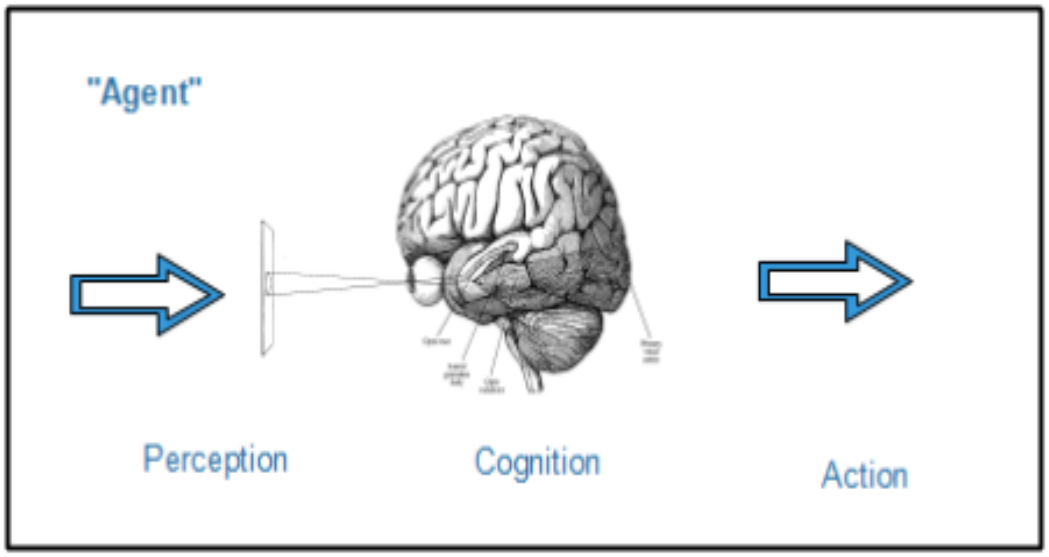

Figure 3.2 AI steps source: Martial Hebert and Mike Lewicki (2007)

Where an agent according to David Poole and Alan McWorth is something that acts in an environment and does something like worms, dogs, thermostats, airplanes, robots, humans, companies, and countries. AI can be applied in natural language processing, Intelligent retrieval from database, expert systems, theorem proving, robotics, combinatorial and scheduling problems, perception problems, neural architectures and game theory.

Read: https://en.wikipedia.org/wiki/Artificial_intelligence

Activity Details

In this activity, you are required to read and research more on AI; History, Applications, Future, Limitations, solutions, relation with other technologies and its future. Check the reference section for this unit for reading materials. You can also acquire more reading material from reliable source in the internet (journals and other publications). At the end of this activity, you will be required to create a summary of;

- History of AI
- Why study AI as an emerging technology
- Components of AI
- Applications of AI
- Limitations of AI (or AI's critical issues)
- Solutions to the issues
- The relationship of AI with Nanotechnology, Robotics, Biotechnology, Neural networks and expert systems.
- Future of AI

This activity will be graded out of 50 (instructor to distribute)

Conclusion

At this point, the student should be knowledgeable on the various applications of AI and why AI is still an emerging technology even though it has been around for more than a decade. The activity also tried to help the student understand the relationship of AI with other technologies and from these the student should now be able to predict the future of AI.

Assessment

1. List three features that define intelligence. (3 marks)
2. Name any two recent breakthroughs in AI or any success stories. (4 marks)
3. What do the critics of AI say, is AI worth the verdict? and what is your opinion? (4marks)
4. Discuss how AI can be applied in;

   E-commerce (4 marks)

   Agriculture (4 marks)

   Manufacturing industry (4marks)

   medicine (4 marks)

   E-tourism (4 marks)

Activity 3.3 - Affective computing.

Introduction

Can you even imagine this!

Computers are beginning to acquire the ability to express and recognize affect, and may soon be given the ability to "have emotions.» Picard R. W.

Now, what is affective computing?

Affective Computing is computing that relates to, arises from, or deliberately influences emotion or other affective phenomena (Picard, 2000). Emotion is natural to humans. It shows human experience, influences cognition, perception, and everyday tasks such as learning, communication, and even rational decision-making. Affective Computing aims to bridge the divide between the highly emotional human and the emotionally challenged computer by developing computational systems that recognize and respond to the affective states like moods and emotions of the user. This is a very important development in the area of Human Computer Interaction (HCI). Affective computing can be traced back to neurology, medicine, and psychology. It implements a biologistic perspective on emotion processes in the brain, body, and interaction with others and with machines.

According to Boehner et al (2005), affect is often seen as another kind of information which involves discrete units or states which are internal to an individual and can be transmitted in a loss-free manner from people to computational systems and back. Affection description can be defined in two ways; first, discrete emotion description like Happiness, fear, sadness, hostility, guilt, surprise, interest (see figure 3.3) and second, dimensional description which include; Pleasure, arousal, dominance.

Figure 3.3 Discrete emotions

Affection detection sources include facial expression, speech/vocal expression, gesture like limbic movements, text and bio-signals (Psychological sensors, Wearable sensors) like brain signal, skin temperature, blood pressure, heart rate, respiration rate. In facial recognition, the images pass through a face detection algorithm, face expression feature extraction and finally an automatic facial expression recognition. The widespread approach in the design of affective computing applications is to construct an individual cognitive model of affect from what is often referred to as "first principles", that is, the system generates its affective states and corresponding expressions from a set of general principles rather than having a set of hardwired signal-emotion pairs. This model is combined with a model that attempts to recognize the user's emotional states through measuring the signs and signals we emit in face, body, voice, skin, or what we say related to the emotional processes going on.

Activity Details

This activity requires you to read and research more on affective computing; History, applications, limitations, solutions, relation with other technologies and its future. Get content fromhttps://en.wikipedia.org/wiki/Affective_computing, Picard,2000 and check the reference section for more reading materials material. At the end of this activity, you will be required to create a summary of;

- History of affective computing (what inspired this technology?)
- Why study affective computing as an emerging technology
- Components of affective computing
- Applications of affective computing
- Limitations of affective computing (or its critical issues)
- Solutions to the issues
- The relationship of affective computing with AI, Ubiquitous and pervasive computing, robotics, Virtual reality, wearable computing and neuroscience.
- Future of affective computing

Conclusion

Affective computing is the study and development of systems and devices that can recognize, interpret, process, and simulate human affects. It is an interdisciplinary field spanning computer science, psychology and cognitive science. From the study, you discovered that areas of affective computing include detecting and recognizing emotional information as well as emotion in machine which is the design of computational devices proposed to exhibit either innate emotional capabilities or that are capable of convincingly simulating emotions. This technology can be applied in learning environment and robotic systems

Assessment

1. Discuss how affective computing is applied in security, medical sector, neurology, psychiatry, dialog/automatic call centre environments (18 marks)
2. Are there any success stories (where they have been applied) for affective computing. Find out and give a summary. (5 marks)

Activity 3.4 - Cloud Computing.

Introduction

The world now is a very small village--as they always say. Technology has made this possible and we can always transact without limits. Where are we headed? This is what you will have to find out. Cloud is the fastest growing component of data center traffic and it was anticipated to grow by more than 30% of the total by year 2015 (Rajesh-CISCO). With its growing popularity, tools and techniques are emerging to build, access and maintain the clouds. Cloud computing refers to the hardware systems, software and applications delivered as services over the internet see figure 3.4.

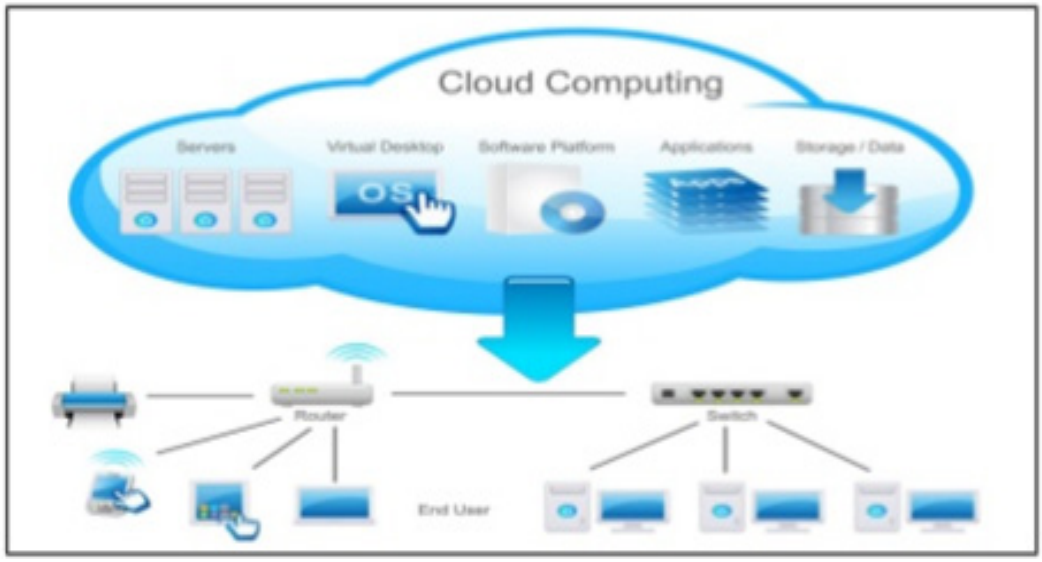

Figure 3.4 Cloud computing Source: Talsaniya (2015)

Naturally, the cloud is everywhere which means we can access resources anytime, any place as we wish see figure 3.5 on access anywhere.

Figure 3.5 Data access anywhere with cloud

There are four major cloud deployment models; public, private, community and hybrid. The models describe how resources within the cloud are shared. A cloud interact with the client which can be a user or an application in a variety of ways, through capabilities known as services. At the moment, common cloud services include; Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

Cloud computing come with various benefits see figure 3.6;

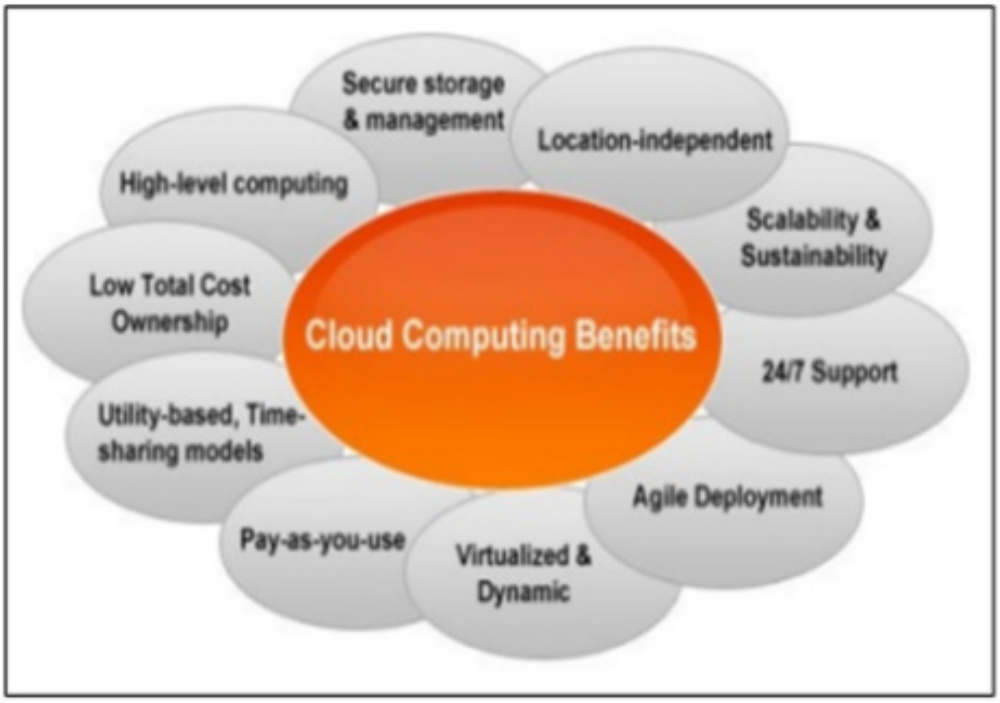

Figure 3.6 Benefits of cloud computing Source: Talsaniya (2015)

Read: https://en.wikipedia.org/wiki/Cloud_computing

Activity Details

This activity entail reading and researching. This materials have been presented in the reference section. Also, you are required to read other articles like the one cited; see reference by Buyya et al (2009). After reading, do a quick summary of;

- the roots of cloud computing,
- cloud computing service models,
- Pertinent issues related to cloud computing
- Its applications.
- Relation of cloud computing to grid, Green IT, Social media/web 2.0 and mobile computing
- Solutions to cloud computing issues
- Future of cloud computing.

Conclusion

We defined cloud computing as a technology also known as on-demand computing, is a kind of Internet-based computing that provides shared processing resources and data to computers and other devices on-demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources. Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centres. Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort. It has become a highly demanded service or utility due to the advantages of high computing power, cheap cost of services, high performance, scalability, accessibility as well as availability. Some cloud vendors are experiencing growth rates of 50% per annum.But due to being in a stage of infancy, it still has pitfalls that need proper attention to make cloud computing services more reliable and user friendly. Some integration and data management providers have also embraced specialized applications of PaaS as delivery models for data solutions. Examples include iPaaS and dPaaS. iPaaS (Integration Platform as a Service) enables customers to develop, execute and govern integration flows.Under the iPaaS integration model, customers drive the development and deployment of integrations without installing or managing any hardware or middleware. dPaaS(Data Platform as a Service) delivers integration—and data-management—products as a fully managed service.Under the dPaaS model, the PaaS provider, not the customer, manages the development and execution of data solutions by building tailored data applications for the customer. dPaaS users retain transparency and control over data through data-visualization tools.Platform as a Service (PaaS) consumers do not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but have control over the deployed applications and possibly configuration settings for the application-hosting environment.

Assessment

1. Discuss the impact of cloud computing on organizations (Business, learning institutions, government etc) and social life
(10 marks)

2. In unit 2, we looked at mobile computing, internet of things, Robotics, Remote sensing and Virtual reality (augmented reality) under ubiquitous and pervasive computing. Relate these technologies with other technologies like AI, Affective computing and cloud computing.
(30 marks)

Unit Summary

This unit gave an overview of other emerging technologies and their relationship with one another. This greatly improves student understanding of how technology converge forming new technologies thus ever changing and evolving technologies.

Unit Assessment

Check your understanding!

1. What do you understand by the word technological convergence?
(2 marks)

2. Technology convergence offers massive opportunities. Name and discuss any two opportunities (4 marks)

3. Give the advantages and disadvantages of robotics. Two each
(4 marks)

4. Name any two applications of each of the following
(4marks)

   i. Robotics

   Ii. AI

Grading scheme

Each activity has been allocated marks. Compute cumulative marks for all the activities in unit 3 then convert to 5%

Feedback

1. Technological convergence is defined as a process by which telecommunications, information technology and media, sectors that originally operate largely independent of one another are growing together OR it is the tendency for different technological systems to evolve towards performing similar tasks

2. Any two opportunities of convergence

   - Increased market competition
   - Emergence of new services and applications
   - Convenience and simplicity

3. **Advantages**

   - Quality and accuracy of work
   - Quality of production
   - Industrial robotics
   - Medical and healthcare robotics
   - Robotics in household

   Disadvantages

   - Loss of jobs in factories
   - Requires a lot of power
   - Requires skilled person for maintenance
   - Expensive to make or buy

3. Applications

   i. Robotics:

   - Industrial robots
   - Domestic or household
   - Medicine/healthcare
   - Service robots
   - Military

- Entertainment
- Space robots

ii. AI:

- Pattern recognition
- Optical character recognition
- Handwriting recognition
- Speech recognition
- Face recognition
- Artificial Creativity
- Computer vision, Virtual reality and Image processing
- Diagnosis (artificial intelligence)
- Game theory and Strategic planning
- Game artificial intelligence and Computer game bot
- Natural language processing, Translation and Chatterbots
- Nonlinear control and Robotics

Unit Readings and Other Resources

- Rajendra Akerkar (2005). Introduction to AI. Prentice Hall. New Delhi, India
- David Poole and Alan Mackworth (2010). Artificial Intelligence. Foundations of Computational Intelligence. Creative Commons. Canada. Available online:http://artint.info/html/ArtInt_3.html
- John McCarthy (2007). What is Artificial Intelligence? Available:http://www-formal.stanford.edu/jmc/whatisai/whatisai.html
- Papadakis, Stelios (2009) Technological convergence: Opportunities and Challenges, 2-3. Available:https://www.itu.int/osg/spu/youngminds/2007/essays/PapadakisSteliosYM2007.pdf
- Boehner Kirsten, DePaula Rogers, Dourish Paul and Senger Pheobe (2005). Affect: from information. ACM, Newyork.
- Rafael A. C., Sidney D'mello, Jonathan G., Arvid K. (2014). The Oxford Handbook of Affective Computing. illustrated, Oxford University Press
- Hook, Kristina (2014): Affective Computing. In: Soegaard, Mads and Dam, Rikke Friis (eds.). «The Encyclopedia of Human-Computer Interaction, 2nd Ed.». Aarhus, Denmark: The Interaction Design Foundation. Available online at https://www.interaction-design.org/encyclopedia/affective_computing.html
- Nikos Antonopoulos & Lee Gillam (2010). Cloud Computing: Principles and Networks. (Illustrated) Springer Science & Business Media.
- Kris Jasma (2011). Cloud Computing. SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile Security and more. (illustrated). Jones & Bartlett.
- Rajkumar Buyya, James Brobery & Andrezes M. Goscinski (2010). Cloud computing: Principles and Paradigms. John Wiley & Sons.
- VR, Talsaniya (2015). Cloud Computing- An emerging Technology & Cloud Computing Models.
- R. Buyya, et al., Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility, Future Generation Computer Systems (2009), doi:10.1016/j.future.2008.12.001
- Rajesh Rege, Cloud Computing: Emerging Trends. CISCO
- Borko Furht & Armando Escalnt (2010). Handbook of Cloud Computing. Computer Science. Springer Science & Business Media.

The readings in this unit are to be found at course level readings and other resources.

Unit 4. Collaborative Innovation

Unit Introduction

As we had seen earlier, innovations starts from a source which either a lab or a small firm which is dedicated in making ideas a reality. Technology too is becoming increasingly dynamic; new ideas are 'borne' each day, conceptualized and are actualized. In this case, the small firm or an individual innovator needs the support of other firms (in this case more stable, large firms) in order to succeed in their innovations. Innovators need the market and to actualize their product which calls for collaborative innovations. Therefore in unit we shall have a general overview of innovation, benefits of innovations to small firms or innovators, challenges that innovators face, collaborations between academia, industry and the governments and last but not least is look at some examples of collaborating firms. This unit will serve as an eye opener to you (student) as an innovator to understand few issues that come with innovations and probably come up with the solutions

Unit Objectives

Upon completion of this unit you should be able to:

- Explain what an innovation is
- Describe the success factors of innovations
- Develop collaboration models
- Identify innovation and their developmental impediments in your institution and country

Key Terms

Innovation:as the successful commercialization of novel ideas, including products, services, processes and business models – is a critical component of economic growth (WEF, 2015)

Collaborative innovation: is an open innovation strategy that enables consumer packaged goods (CPG) manufacturers and retailers to partner for profit and provide shoppers and consumers with more innovative offerings (http://viewpoints.io/uploads/files/Best_Practices_in_Collaborative_Innovation_1.pdf).

R & D: Systematicactivity combining both basic and applied research, and aimed at discovering solutions to problems or creating new goods and knowledge.

Learning Activities

Activity 4.1 – Overview of innovations

Introduction

Emerging technologies evolve as innovations which start with a conceived idea. And as we had seen earlier, these innovations are increasing at a rapid rate. This activity therefore looks at definition of innovation (what innovation is), factors influencing the success of an innovation and barriers to innovations. This will guide us to understand the nature of innovations and probably prepare us while planning to undertake one.

Activity Details

What is an innovation?

Let us start with this story...

Mary Anderson visited New York City in the winter of 1902 in a trolley car. It was on a frost day. Mary noted the motorman drove with both panes of the double front window open because of the difficulty of keeping the windshield clear of falling sleets. Probably the car could stop at some point in the journey for the screen to be wiped manually so as to enhance visibility. When Mary returned to Alabama (her home), she hired a designer for a hand-operated device to keep a windshield clear and had a local company produce a working model. She applied for and in 1903 was granted a seventeen year patent for a windshield wiper.

Mary conceived an idea from what she experienced. The idea was conceptualized and actualized. Innovation therefore is the successful commercialization of novel ideas, including products, services, processes and business models – is a critical component of economic growth (WEF, 2015). Mary's idea increased economic growth.

Requirements for developing an innovation

HSC online provided nine key elements present in successful industrial innovations and these include;

- **Identifying the market opportunity**: an innovation becomes successful whenever the innovator has a consumer in mind
- **Obtaining and managing resources:** ability to identify and access resource is one key factor in the success of an innovation. Management of the same resources like people, funds etc is also important as it keeps the innovation on course.
- **Research and development:** research helps innovators acquire more skills and help them to learn if other similar products exist in the market. This helps in avoiding reinventing an existing product. One also has to research on the market, the needs of the users or consumers of the product.

- **Protecting intellectual property**: one may need to protect the text, artwork, logo, name, methods etc and this may imply applying for a trademark or a patent or a copyright or all of them.
- **Product design**: here we consider the functionality of the product, aesthetics etc. The product may be aesthetically good but not functional or vice versa. Hence a balance of all the product design attributes is important.
- **Supplies**: Do you have consistent supply of raw materials? are they sustainable or reliable?
- **Manufacture**: Computer technology has changed the way machines operate. The use of computer based technologies means that products can be produced faster and with greater consistency. But consider this, are small product runs still done best with traditional machines? what is the capability of the manufacturer in terms of technology applied in producing the products? Do you have the capacity to produce products and meet the demands of the market.
- **Promotion**: Do you have a promoter to inform the public about the new product. This creates awareness and greater diffusion and adoption of the innovation.
- **Distribution**, sales and services: there must be reliable supply of the same product in the market. Hence distribution logistics must be factored in.

Factors influencing the success of an innovation

Despite various challenges experienced during innovation development, there are also a number of factors that can influence the success of innovations. These critical factors are (HSC online):

1.Effort and risk: Innovators need to put desired effort to their innovations. They have to be focused and consistent in their attempts. Innovators also need to assess risks throughout the innovation development. This will help increase the chances of innovation success within estimated time and budget.

2.Managing all the elements of industrial innovation: All of the nine requirements need to be constantly addressed either by the individual innovator or innovation firms.

3.Seeking out sources of innovation: Innovation is not limited to manufacture, in terms of tools and raw materials but it needs to extend to other critical areas of the project like being innovative in packaging, branding, marketing among others. This means that innovation is an ongoing process.

4.Integration of all elements in industrial innovation: The nine key requirements constantly influence each other. In other words, a change in one element may modify the status of the others. Therefore, monitoring and managing the proposed changes is critical to the success of the innovation.

5.Continuing improvements: The product needs to be constantly improved to remain relevant in the world of vast growing and emerging technologies. This will also deter rival products from stealing your market. Consider the improvements made to Mary Anderson's wiper innovation with the ongoing work on the same innovation.

6.Sustained investment: Majority of innovations which are successful over time have a considerable investment made in terms of time, finances, energy and determination.

Read more on barriers from HSC online (see reference for the link).

Barriers to innovations

"The road to success is not always easy". For this reason, innovators face myriad of challenges in their endeavors. The common barriers (IBM, 2006) include:

1. Inadequate funding:
2. Risk avoidance
3. "Siloing"
4. Time commitments
5. Incorrect measures

Read more on barriers from IBM, (2006) page 1-6 (http://www.935.ibm.com/services/igs)

Activity 4.1 assignment

1. Find out what motivated Josphine Cochran to invent a dishwasher? What lessons can you (as an innovator) draw from Josphine's attempt
2. Identify barriers that might hinder the growth of innovations in your
   i. Institution
   ii. Country

Activity 4.2 - collaborations between academia, industry and the governments

Introduction

Collaborative innovation is the engine of modern, agile organizations capable of creating new capacity, which can pioneer radical new ideas while testing the limits of markets (WEF, 2015). To make certain that innovations grow into job creating commercial products, and services, government industry and academia must collaborate throughout innovation process. This unit looks at the benefits of collaborative innovations between academia, industry and government.

Activity Details

Collaborative innovation

Innovation is a difficulty and ambiguous endeavour which normally requires knowledge and/ or inputs from various sources. "In order to retain some element of management control over these inputs, firms' relationships with external organizations are often formalized into "collaborations". Hence, collaboration is includes any activity where two or more partners contribute differential resources and know – how to agreed complementary aims" (Dodgson,1994)- page 1 and 2. Collaboration can be vertical or horizontal (read Dodgson on these two types of collaborations). Collaboration between firms can take can take the form of R&D contracts or technology exchange agreements whereby firms' shared objectives involve the interchange of research findings or technological know – how. Where such relationships abound among groups of firms they are sometimes described as "innovation networks".

WEF(2015) discussed the capabilities of young dynamic firms and established companies. These include (refer to table 4.1):

Table 4.1 Capabilities of young, dynamic firms and established companies source(WEF,2015)

	Young, dynamic firms	Established firms
Capabilities	Closer to sources of technological knowledge, such as universities and research centers • Higher degree of flexibility • Nimbler response to market signals • Proficiency in a specific niche	• Resources, experience and knowledge to successfully commercialize new offerings • Spread of R&D costs over an extensive and diversified sales base • Sophisticated IP protection and management due to experience and resources • Less threatened by litigation • Regulatory and compliance expertise • Market reach

Challenges	• Scarcity of resources, few physical assets (that banks can use as collateral), and limited record of success • Lack expertise outside of core offerings • Lack of scale, distribution channels, and marketing know-how • Competition, market entry problems, and poor infrastructure • Insufficient understanding of innovation's full • applicability and potential	• Possible bureaucracy and inertia, leading to • slower information flow, less flexibility and less creative thinking • Less access to new technologies and state-of-the-art engineering • Risk-averse culture

Read WEF, (2015) page 8 and 9 to understand innovative collaborations between young dynamic firms with established companies.

Seven keys to collaboration success by Pertuze et al, (2010)include:

- Define the project's strategic context as part of the selection process
- Select boundary spanning project managers with three key attributes (refer to link on reference)
- Share with the university team the vision of how the collaboration can help the company invest in long term relationships
- Establish strong communication linkage with the university team
- Build broad awareness of the project within the company
- Support the work internally both during the contract and after until the research can be exploited.

Read Pertuze et al (2010) for more content on these keys to collaboration success.

Collaboration among industry, academia, and government not only leads to the development and commercialization of innovative new products, but exchanges with universities also offer a variety of benefits, including: cultivating talented personnel, accumulating state-of-the-art know-how, and generating a positive impact on your brand in terms of sales and marketing, and its synergistic effect is immeasurable. Therefore, the benefits of Industry/Academia/Government Collaboration include (https://www.meijo-u.ac.jp/english/research/collaboration.html):

- Development of technologies and products that are difficult to implement on one's own
- Introduction of advanced specialized technologies, know-how, and expertise

- Use of state-of-the-art facilities
- Nurturing of human resources
- Making connections with new networks of contacts

Academia-industry collaborations has its own pros and cons which include (Pronk et al,2015) see table 4.2:

Table 4.2 Pros and cons of industry-academia collaborations source: (Pronk et al, 2015)

Benefit or risk	Industry partner	Academic partner
Pros	Access to specialized, world-leading skills and resources Ability to develop and screen new talent for hire Cost-effectiveness of research Out-of-box thinking Training in fundamentals Access to extended networks Informed consulting and Science Advisory Board contributions	Inspiration of academic research by application-derived questions Career opportunities for students Funding for research; consulting income Launch pad for young, rising professors Awareness of trends in industry Options to build centers and consortia Practical application of academic research and skills
Cons	Lack of IP protection Incompatible priorities (e.g., immediate applicability vs. fundamental understanding) Partners at different locations with different management cultures Typical length of PhD and postdoc projects reduces flexibility	Restricted freedom to share IP Incompatible priorities (e.g., education vs. commercial interests) Partners at different locations with different management cultures Restricted ability to collaborate with other partners

WEF, (2015) developed a collaboration model that can be applied by innovators, firms and companies. The model is as shown below:

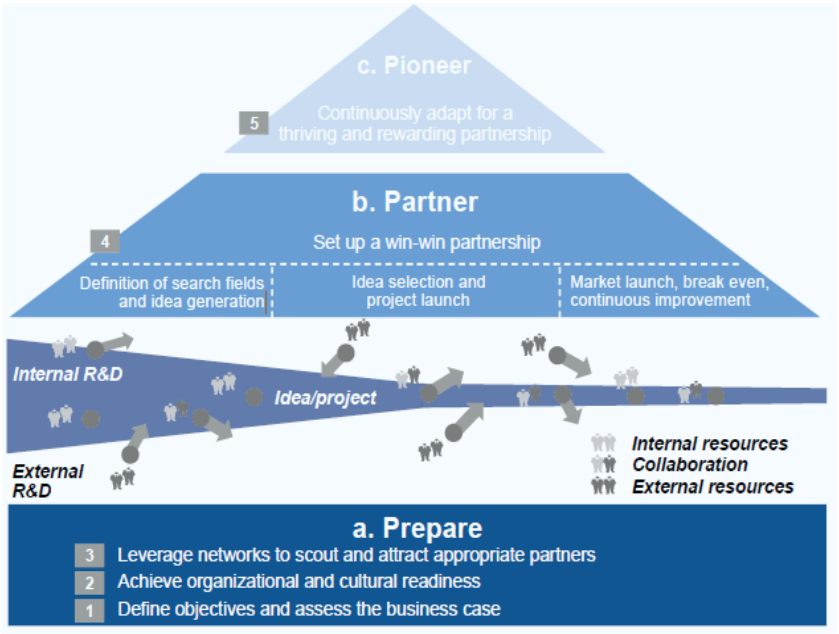

Figure 4.1 Collaborative innovation models source: (WEF,2015)

Read WEF, (2015) page 11and 19 to understand collaborative innovations model between young dynamic firms with established companies.

Pronk et al, (2015) discusses four different modes of collaboration between academia and industry which include:

- consulting,
- contract research,
- bilateral partnerships and
- public private partnerships (PPPs)

Advantages of different collaboration models are as shown on table 4.3:

Table 4.3 Advantages of different collaboration models source: (Pronk et al, 2015)

Model	Advantage for industry	Advantage for academia
	Outside ideas: industrial projects are typically staffed to execute on a defined plan. Outside domain experts add new ideas to improve on the plan, rigor to the assessment of progress, and insights to overcome hurdles.	Scientific discussions: consultancy offers a wonderful 'playground' to escape academic management and sharpen academic minds on new, challenging commercial projects as well as understand commercial realities of translating research.

Consultancy	Networking: good consultants know their limits and identify colleagues with strong knowledge in fields outside their own. Independent expert evaluation of internal research programs and strategy. Intellectual property ownership: clear, predefined rules give comfort that technology rights will be protected. This comfort is enhanced when dealing with consultants who have a strong track record of respecting client IP.	Networking: consultancy often leads to other forms of collaboration, such as direct industrial funding of academic research in the consultant's group, joint application for government-funded programs, etc. Financial: provision of financial flexibility in financially challenged academic research groups. Alignment of long-term academic research strategies with industrial interests.
Contract research	Outside expertise and infrastructure to selectively and globally leverage advanced capabilities to benefit industry projects and technology platform building. Cost savings: no need to invest in fixed-cost in-house facilities, particularly for non-core technologies. Speed of research: answers can often be found more quickly by engaging established experts to solve specialized problems. Flexibility: multiple collaborations can be started and stopped as needed according to business priorities.	Networking: contract research can sometimes lead to follow-ups in more open settings. Financial: confidential contract research is generally well paid, and proceeds can be reinvested in infrastructure or fundamental research. In some situations, contract research can serve as 'matching' industrial funding in grant applications for government funding aimed at more open, fundamental research. Alignment of research strategy: enables academics to orient their research to be industrially relevant.

PPPs	Networking: successful PPPs also evolve into popular meeting grounds for industrial scientists from different companies. Critical mass projects: access to and involvement in high-quality, focused industrial-academic research programs with a considerable critical mass (10–100 scientists and PhD students) Recruitment possibilities: observing work offers the advantage of seeing first-hand how students and postdocs perform. Early access to novel techniques and concepts: blue-sky and cutting edge research originating from academia often spurs applied research. Clear and uniform procedures for acquiring IP rights: may have advantages over a myriad of bilateral collaborations.	Networking for PhD students and postdocs: participating young researchers are frequently exposed to leading academic and industrial scientists. Critical mass projects: the critical mass of PPPs enables academic teams to take on challenges that would exceed the possibilities of any individual group. Alignment of resources and shared infrastructures: especially in larger PPPs, activities of different academic partners can be optimally aligned, thus fostering collaboration rather than unproductive competition. Funding: successful PPPs can secure a basal funding of research in a group, allowing continuity in major research lines.

Read Pronk et al, (2015) page 237 to 240 to understand the different collaborative models between the academia and the industry.

Activity 4.2 Assessment

1. Read on four different modes of collaboration between academia and industry then write short notes.
2. Based on WEF,(2015) collaborative innovation model, what does prepare, partner pioneer entail

Activity 4.3 Examples of collaborating firms

Introduction

This activity looks at some examples of collaborating companies with their motivations for the same (collaborations). It also tries to identify the models that they apply (just as we had mentioned previously).

Activity Details

Our first example is IBM's collaborative innovation centres (CIC). The centre has been instituted to work with regional government, academia and business for developing in-demand skills, accelerating research innovations into markets, and driving regional economic development.

Their model is based on integrated learning (teaching/skills), discovery (research), and engagement (application/entrepreneurship) on real-world challenges. Whose focus is on real-world challenges, real-world tools, real-world data, mentors from industries, and leading-edge teaching and research faculty that expand the professional social networks of the students. While education, research and entrepreneurship are the three pillars of CICs', the model is flexible and can be easily modified to meet the regional needs.

Read more on this from http://www.research.ibm.com/university/cic/index.shtml.

Second example is between Microsoft, Intel and TD Bank. Read thios from http://blog.diebold.com/collaboration-innovation-part-4-insights-from-microsoft-intel-and-td-bank/

Activity 4.3 Assessment

1. Find out any three innovations in your institution that are developed in collaboration with other institutions.
2. Which model do they apply?
3. Based on the two examples IBM's with Microsoft's collaborative ventures in activity 4.3, do a summary of the impacts of collaborative innovations to business.

Grading scheme

Each activity has been allocated marks. Compute cumulative marks for all the activities in unit 3 then convert to 5%

Unit Summary

In order to make certain that innovations grow into job creating commercial products, and services, government industry and academia must collaborate throughout innovation process. Collaboration among industry, academia, and government not only leads to the development and commercialization of innovative new products, but exchanges with universities also offer a variety of benefits, including: cultivating talented personnel, accumulating state-of-the-art know-how, and generating a positive impact on your brand in terms of sales and marketing, and its synergistic effect is immeasurable. Therefore, the benefits of Industry/Academia/ Government Collaboration include development of technologies and products that are difficult to implement on one's own, introduction of advanced specialized technologies, know-how, and expertise, use of state-of-the-art facilities, nurturing of human resources and making connections with new networks of contacts

Unit Readings and Other Resources

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Module Summary

This module defined ETs as technologies which are under development and bear high degree of uncertainty to the market or industry. They may comprise new or old technologies with the the ability to create a new industry or change an old industry. ETs hold various characteristics that can be used for identification. At the same time, computing technologies are applied to various fields that affect our daily activities like communication, agriculture, transportation, entertainment and many more others. ETs have a number of impacts which can be desirable or undesirable to the society and organizations. Organizations need to leverage on these impacts in order to remain relevant and competitive. At the same time the society need to keep pace with these technologies in order to improve their well-being and decision making. Technologies emerge from various sources which include small labs or firms that are dedicated to research in various fields. These technologies are later picked-up by other interested firms leading to cooperation between originating firms, organizations, users (consumers) as well as other research firms.

Technology in the area of computing has come along way from the mainframe era to desktop era to pervasive computing era which is marked by large number of computers in the world that are smaller in size. Pervasive computing is also known as ubiquitous computing. The aim of ubicomp is to create devices that disappear to the user's background. These devices need to have high degree of intelligence. Distributed systems together with mobile computing technologies served as stepping stones towards computer ubiquity. Various technologies in engineering, computer science and software engineering greatly influence the emergence and proliferation of ubicomp. These include sensor technology, biometrics, RFID, artificial intelligence, human computer interaction, networking among others. These means ubicomp is as a result of technology convergence. As much as ubicomp technology being accepted in the world, it also has issues that need to be addressed for it to gain high level acceptance. With the proliferation of this technology, it is expected that there will be millions to billions of smart, intelligent system in the word which will supersede human population. Therefore, ubicomp will continue to emerge and be the technology to be watched in the coming years.

This module also gave an overview of other emerging technologies and their relationship with one another. This greatly improves student understanding of how technology converge forming new technologies thus ever changing and evolving technologies.

In order to make certain that innovations grow into job creating commercial products, and services, government industry and academia must collaborate throughout innovation process. Collaboration among industry, academia, and government not only leads to the development and commercialization of innovative new products, but exchanges with universities also offer a variety of benefits, including: cultivating talented personnel, accumulating state-of-the-art know-how, and generating a positive impact on your brand in terms of sales and marketing, and its synergistic effect is immeasurable. Therefore, the benefits of Industry/Academia/Government Collaboration include development of technologies and products that are difficult to implement on one's own, introduction of advanced specialized technologies, know-how, and expertise, use of state-of-the-art facilities, nurturing of human resources and making connections with new networks of contacts

Course Assessment 1

1. What is an emerging technology?
   (2 Marks)
2. Give any five characteristics of emerging technologies
   (5 Marks)
3. Define the word technology convergence
   (2 Marks)
4. Explain three features that influenced the evolution of pervasive computing (ubicomp) (6 Marks)
5. Discuss any five characteristics of ubiquitous computing
   (10 marks)
6. Explain any three challenges of Ubiquitous computing
   (6 marks)
7. What is the impact of ubiquitous and pervasive technologies to individuals and organizations (businesses)
   (5 marks)
8. Discuss any five requirements for developing an innovation
   (10 marks)
9. Define affective computing? and why it an important emerging technology? (2 marks)

Course Assessment 2 (Application)

Suppose you were employed in organization X in your country as a student trainee . X is among the largest organizations in the country. To become a full employee of the organization, you will be required to design a product that will improve citizens lives in your country. It must have operability characteristics to be able to work with X's existing systems. Select one X in your country from among the largest organizations that invests a lot in IT. What kind of product will you design, what motivates your innovation and what are its contributions both to the society and organization X, which is your target population (users), what success factors will you consider for this kind of population, which technologies do you require for your project, do you think it has the potential of being part of ETs (Explain), Which requirements will you consider during design, which collaboration model will you apply and what are some of the challenges that you may face in product development and /or what are some of your fears about the endeavor, how do plan to address these fears.
(30 marks)

Grading scheme

Each activity has been allocated marks.

Feedback

Solutions: Course Assessment 1

1. An emerging technology involve a wide range of technologies that are still at the research stage and therefore off the radar of policymakers, but will in time have transformative effects ranging from the emergence of new industries, by disruption of current value chains, to major societal changes in the fields of healthcare and communications

2. Characteristics of emerging technologies include:

   - Uncertainty and ambiguity
   - ETs may or may not be new technologies
   - Creative destruction (potentially disruptive)
   - Relative fast growth
   - Coherence and persistence
   - Complex and fuzzy
   - The expanding knowledge base
   - The application to the existing markets is undergoing innovation

3. Technology convergence is defined as a process by which telecommunications, information technology and media, sectors that originally operate largely independent of one another are growing together OR it is the tendency for different technological systems to evolve towards performing similar tasks

4. Any three

   - Distributed systems and
   - Mobile computing.
   - Sensor networks
   - Human computer interaction
   - Artificial intelligence

5. Characteristics of Ubicomp:

   - Miniaturisation: the core idea is reducing the size of devices to allow ease of mobility by humans at the same time achieve the idea of invisibility

- Embedding: ubicomp devices are embedded into other components or objects.
- Networking: they rely on connectivity for ease of communication. The connection occur at the time of use and ceases when not in use.
- Ubiquity: This describe ubicomp technology as a situation in which the users are surrounded by various embedded systems which are mostly invisible and weaved into the background of the surrounding, like appliances and they communicate via a network or are interconnected
- Context awareness: ubicomp technologies are able to capture the information about the environment of their operations and react appropriately. Example of context include time and location. In other words, they capture the context, assign meaning and change behaviour accordingly. This attribute aid in personalization of services.
- Limited power: because of their size ubicomp technologies consume less power. One small cell is able to run the device for a number of years or throughout its lifespan.

6. Three challenges of Ubiquitous computing. Student can explain,

- The "Accidentally" Smart Environment
- Impromptu interoperability
- No system administrator
- Social implications of aware technologies
- Reliability

7. Impact of ubiquitous and pervasive technologies to individuals and organizations (businesses): Student can discuss,

- Shifting value chains
- Digitization of goods
- Shifting locus of innovation to outside the firm
- Informatics for Adding Value to Information Innovations in how information is organized, mined and processed help minimize or filter the amount of noise generated on daily basis and hence the use the growing wealth of global information to address emerging challenges.
- Synthetic Biology and Metabolic Engineering
- Green Revolution 2.0
- Nanoscale Design of Materials
- Systems Biology and Computational Modeling/ Simulation of Chemical and Biological Systems
- Using Carbon Dioxide as a Resource
- Wireless Power Society
- High Energy Density Power Systems.

- Personalized Medicine, Nutrition and Disease Prevention.
- Enhanced Education Technology.

8. Any five requirements for developing an innovation. Student can discuss,

- Identifying the market opportunity
- Obtaining and managing resources
- Research and development
- Protecting intellectual property
- Product design
- Supplies
- Manufacture
- Promotion
- Distribution, sales and services

9. Affective computing is the study and development of systems and devices that can recognize, interpret, process, and simulate human affects. It is an interdisciplinary field spanning computer science, psychology and cognitive science and why it an important emerging technology because it is still under study and has emerging technologies characteristics (Student to mention relating characteristics)

Solutions: Course Assessment 2

The instructor will be required to assess this assessment against the properties of emerging technologies as well as characteristics of innovations and the success factors

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