Influence of Artificial Intelligence on Communication Systems

by

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Highlights of my talk

- ***Timeline of Telecommunication related technology***
- ***Timeline of Artificial Intelligence related technology***
- ***Timeline of AI events***
- ***Modern digital communications***
- ***AI vocabulary*** – *Intelligence, knowledge, learning, Knowledge Model, Knowledge typology map*
- ***Building Intelligent Communication Systems -*** *Intelligent Mobile Platform, Voice-Recognition across Mobile-Phone, and Knowledge Based Networking.*
- ***Conclusion***

Influence of Artificial Intelligence on Communication Systems

- *The telephone is one of the most marvelous inventions of the communications era : the physical distance is conquered instantly.*
  - *any telephone in the world can be reached through a vast communication network that spans oceans and continents.*
  - *the form of communication is natural, namely human speech.*

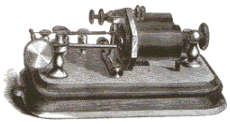
- *Communication is no more just two persons talking, it is much more.*
  - *human communicate with a knowledge source to gather facts ,*
  - *human communicate with an intelligent systems for solving problems requiring higher mental process,*
  - *human communicate with experts to seek specialized opinion,*
  - *human communicate with logic machines to seek guidance,*
  - *human communicate with reasoning systems to get new knowledge, and*
  - *human communicate for many more things to do.*

- *Advances in communication technologies have led to increased worldwide connectivity while new technology like cell-phone has increased mobility*.

▶ Timeline of Telecommunication related technology

Roots of Communication : The development of communication systems began two centuries ago as wire-based electrical systems called telegraph and telephone. Before that it was human messengers, 200 to 100 BC, on foot or horseback. Egypt and China built messenger relay stations.

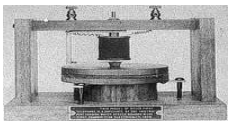
Electric Telegraph, 1831 , invented by Samuel Morse.



Morse code, 1835, invented by Samuel Morse, a method for transmitting telegraphic information.

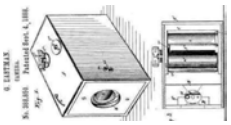
Typewriter, 1867, invented by Christopher Latham Sholes, as the first practical typewriting business offices machine.

Telephone, 1875, invented by Alexander Graham Bell, an instrument through which speech sounds, not voice, were first transmitted electrically.

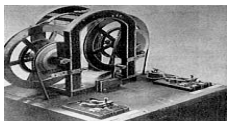


Telephone Exchange, 1878, a Rotary Dialing system, became operational in New Haven, Connecticut.

Kodak Camera, 1888, invented by George Eastman and introduced Rolled Photographic Film.



Telegrafoon, 1899, invented by Valdemar Poulsen, was a tape recorder; recording media was a magnetized steel tape.

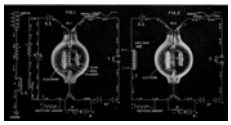


Wireless telegraphy, 1902, Guglielmo Marconi transmitted MF band radio signals across the Atlantic Ocean, from Cornwall to Newfoundland.

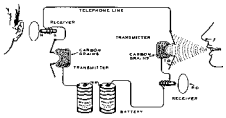
Tx

Rx

Audion vacuum tube, 1906, invented by Lee Deforest, a two-electrode detector device and later in 1908 a three electrode amplifier device.



Cross continental telephone call, 1914, *Graham Bell's, evolution of the Telegraph into the Telephone; the Greek word tele meaning from a far, and phone meaning voice.*



Radios with tuners, 1916, a technological revolution of its time, pilots directed gunfire of artillery batteries on ground through wireless operator attached to each battery.

Iconoscope, 1923, invented by Vladimir Zworykin, a tube for television camera needed for TV transmission.

Television system, 1925, invented by John Logie Baird, transmitted TV signal in 1927 between London and Glasgow over telephone line.

Radio networks, 1927, is a system which distributes programming (contents) to multiple stations simultaneously, for the purpose of extending total coverage beyond the limits of a single broadcast station.

- *radio broadcasting is traditionally through air as radio waves; it can be via cable, FM, local wire networks, satellite and internet.*
- *stations are linked in radio networks, either in syndication or simulcast or both;*

Note : Syndication is the sale of the right to broadcast radio and television shows to multiple individual stations or a broadcast network. Simulcast is "simultaneous broadcast" refers to programs or events broadcast across more than one medium, or more than one service on the same medium, at the same time.

▶ Timeline of AI related technology

Roots of AI : The development of artificial intelligence actually began centuries ago, long before the computer.

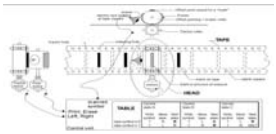
Roman Abacus , 5000 years ago, machine with memory,

Pascaline, 1652 , Calculating machines that mechanized arithmetic ,

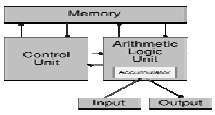
Diff. Engine, 1849 , Mechanical calculating machines programmable to tabulate polynomial functions.

Boolean algebra, 1854, " Investigation of laws of Thought" symbolic language of calculus.

Turing machines, 1936, abstract symbol-manipulating devices, adapted to simulate the logic, is the first computer invented (on paper only).



Von Neumann architecture, 1945, Computer design model, a processing unit and a shared memory structure to hold both instructions and data.



ENIAC, 1946, "Electronic Numerical Integrator and Calculator" the first electronic "general-purpose" digital computer by Eckert and Mauchly.

Timeline of AI events

The concept of AI as a true scientific pursuit is a very young. It remained over centuries a plot for popular science fiction stories. Most researchers agree the beginning of AI with Alan Turing.

1950, Turing test, by Alan Turing, in the paper "Computing Machinery and Intelligence" used to measure machine intelligence.
This test called for a human judge to use a computer terminal to interact with human as well as with the machine; if the judge cannot reliably tell which is human and which is machine, then the machine is said to pass the test and the machine would be considered intelligent.

1950, intelligent behavior, Norbert Wiener, observed link between human intelligence and machines, and theorized intelligent behavior.

1955, Logic Theorist, a program by Allen Newell and Herbert Simon, claimed that machines can contain minds just as human bodies do, proved 38 out of the first 52 theorems in Principia Mathematica.

1956, Birth of AI, Dartmouth Summer Research Conference on Artificial Intelligence, organized by John McCarthy, regarded as the father of AI.
This conference lasted a month, was essentially an extended brain-storming session, to draw the talent and expertise of others interested in machine intelligence. The term artificial intelligence was first coined. The Dartmouth conference served to lay the groundwork for the future of AI research and discussed computers, natural language processing, neural networks, theory of computation, abstraction and creativity : all still open research areas.

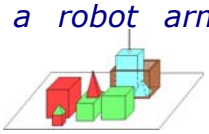
1963, seven years after, AI began to pick up momentum, the field was still undefined, and the ideas formed at the conference were re-examined.
The centers for AI research began forming at Carnegie Mellon and MIT, and new challenges were faced, further research were carried, creating systems that could efficiently solve problems, such as the Logic Theorist and making systems that could learn by themselves.

1957, General Problem Solver (GPS), was tested. The GPS was an extension of Wiener's feedback principle, and was capable of solving to a greater extent the common sense problems.

1958, LISP language, was invented by McCarthy and soon adopted as the language of choice among most AI developers.

1963, DoD's Advanced Research projects started at MIT, researching Machine-Aided Cognition (artificial intelligence), by drawing computer scientists from around the world.

1968, Micro-world program SHRDLU, at MIT, controlled a robot arm operated above flat surface scattered with play blocks.



SHRDLU could plan, carry on simple conversations typed in natural English, like "stack up both of the red blocks and either a green cube or a pyramid".

Mid-1970's, Expert systems, for Medical diagnosis (Mycin), Chemical data analysis (Dendral) and Mineral exploration (Prospector) were developed.

Feigenbum defined an expert system as an intelligent computer program that uses knowledge and inference procedure to solve problems difficult enough and require significant human expertise for their solution. A typical expert system consists of five components : user interface, working memory, the knowledge base, the inference engine, and explanation system.

During 1970's, Computer vision (CV) technology of machines that "see" emerged. David Marr was first to model the functions of visual system.

The purpose of CV is to program a computer to "understand" a scene or features in an image. It is a combination of concepts, techniques and ideas from Digital Image Processing, Pattern Recognition, Artificial Intelligence, and Computer Graphics.

1972, Prolog, by Alain Colmerauer, is a logic programming language .

Logic programming is the use of logic in both declarative and procedural representation language. It is based upon backwards reasoning theorem prover applied to declarative sentences in the form of implications, e.g., :

If B1 and B2 . . . and Bn then H.

Modern digital communications

Shannon, in 1947, created a mathematical theory, which formed the basis for modern digital communications. Since then the developments were :

1960s, three geosynchronous communication satellites, launched by NASA.

1961, packet switching theory, was published by Leonard Kleinrock at MIT.

1965, wide-area computer network, a low speed dial-up telephone line, created by Lawrence Roberts and Thomas Merrill.

Within this network, a time-sharing computer could dial into another computer and remotely run programs on that system.

1966, Optical fiber was used for transmission of telephone signals.

Late 1966, Roberts went to DARPA to develop the computer network concept and put his plan for the "Advanced Research Projects Agency Network - ARPANET", which he presented in a conference in 1967. There Paul Baran and others at RAND presented a paper on packet switching networks for secure voice communication in military use. The observations and the out come of this 1967 conference were :

The work at MIT (1961-1967), at RAND (1962-1965), and at NPL (1964-1967) had all proceeded in parallel without any of the researchers knowing about the other's work. The word "packet" was adopted and the proposed line speed was upgraded from 2.4 kbps to 50 kbps to be used in the ARPANET design."

1968, Roberts and DARPA, revised the overall structure and specifications for the ARPANET, released an RFQ for development of key components: the packet switches called Interface Message Processors (IMP's).

Bolt Beranek and Newman (BBN) won the contract in 1968. They selected a Honeywell minicomputer as the base on which they would build the switch (IMP). The implementation responsibilities of the overall ARPANET were assumed by one or more individual :

- *architectural design - by Bob Kahn.*
- *network topology and economics design and optimization - by Roberts with Howard Frank and his team at Network Analysis Corporation.*
- *data networking technology, network measurement system preparation by Kleinrock's team at University of California, Los Angeles (UCLA).*

The year 1969 saw the beginning of the Internet era, the development of ARPANET, an unprecedented ***integration of capabilities of telegraph, telephone, radio, television, satellite, Optical fiber and computer.***

In 1969 a day after labour day, UCLA became the ***first node*** *to join the ARPANET. That meant, the UCLA team connected the first switch (IMP) to the first host computer (a minicomputer from Honeywell).*

Bits began moving between the UCLA computer and the IMP that same day. By the next day, they had messages moving between the machines. ***Thus was born the ARPANET****. By then Crocker finished the initial ARPANET Host-to-Host protocol, called Network Control Protocol, NCP .*

A month later the ***second node*** *was added at SRI (Stanford Research Institute) and the first Host-to-Host message on the Internet was launched from UCLA. It worked in a cleaver way, means :*

- *Programmers for "logon" to the SRI Host from the UCLA Host - typed in "log" and the system at SRI added "in" thus creating the word "login".*
- *Programmers could communicate by voice as the message was transmitted using telephone headsets at both ends.*
- *Programmers at the UCLA end typed in the "l" and asked SRI if they received it; came the voice reply "got the l".*

By 1969, they connected ***four nodes*** *(UCLA, SRI, UC SANTA BARBARA, and University of Utah). UCLA served for many years as the ARPANET Measurement Center.*

In mid-1970's, UCLA controlled a geosynchronous satellite by sending messages through ARPANET from California to East Coast satellite dish.

By 1970, they connected ***ten node****.*

Note: Bolt Beranek and Newman (BBN) designed the Interface Message Processors (IMP's) to accommodate 64 computers and only one network.

In 1972, the International Network Working Group, INWG was formed to further explore packet switching concepts and internetworking, as there would be multiple independent networks of arbitrary design.

Kahan at DARPA introduced the idea of open-architecture networking. Cerf and Kahn developed an internetworking concept (CATENET) to connect networks, that use different packet types and transmission rates such as a satellite and radio network, with gateways (routers).

In 1973, Kahn developed a protocol that could meet the needs of an open-architecture network environment. This protocol is popularly known as ***TCP/IP*** *(Transmission Control Protocol/Internet Protocol).*

ARPANET Host-to-Host Network Control Protocol (NCP) remained and tended to act like a device driver, while the new protocol would be more like a communications protocol. The idea was to connect a number of different networks designed by different vendors into a network of networks (the "Internet") and deliver a few basic services that everyone needs (file transfer, electronic mail, remote logon) across a very large number of client and server systems.

Note : TCP/IP is named after two of the most important protocols in it.

- *IP is responsible for moving packet of data from node to node.*
- *TCP is responsible for verifying delivery of data from client to server.*
- *Sockets are subroutines that provide access to TCP/IP on most systems.*

In 1976, X.25 protocol was developed for public packet networking.

The X.25 is a standard network protocol adopted by the Consultative Committee for International Telegraph and Telephone (CCITT). It allows computers on different public networks to communicate through an intermediary computer at the network layer level.

In 1977, the first internet, work was demonstrated by Cerf and Kahn. They connected three networks with TCP : the Radio network, the Satellite network (SATNET), and the Advanced Research Projects Agency Network (ARPANET).

In 1980's, the ARPANET was evolved into the INTERNET. Internet is defined officially as networks using TCP/IP.

On January 1, 1983, the ARPANET and every other networks attached to the ARPANET officially adopted the TCP/IP networking protocol. From then on, all networks that use TCP/IP are collectively known as the Internet. The standardization of TCP/IP allows the number of Internet sites and users to grow exponentially.

Today, Internet has millions of computers and hundreds of thousands of networks. The network traffic is dominated by its ability to promote ***"people- to-people"*** *interaction.*

► AI vocabulary

Intelligence relate to tasks involving higher mental processes, e.g., creativity, solving problems, pattern recognition, classification, learning, induction, deduction, building analogies, optimization, language processing, knowledge and many more. Intelligence is the computational part of the ability to achieve goals.

Intelligent behavior is depicted by perceiving one's environment, acting in complex environments, learning and understanding from experience, reasoning to solve problems and discover hidden knowledge, applying knowledge successfully in new situations, thinking abstractly, using analogies, communicating with others, and more.

Science based goals of AI is to develop concepts, mechanisms and understand biological intelligent behavior. The emphasis is on understanding intelligent behavior.

Engineering based goal of AI is to develop concepts, theory and practice of building intelligent machines. The emphasis is on system building.

AI Techniques depicts how we represent, manipulate and reason with knowledge in order to solve problems.

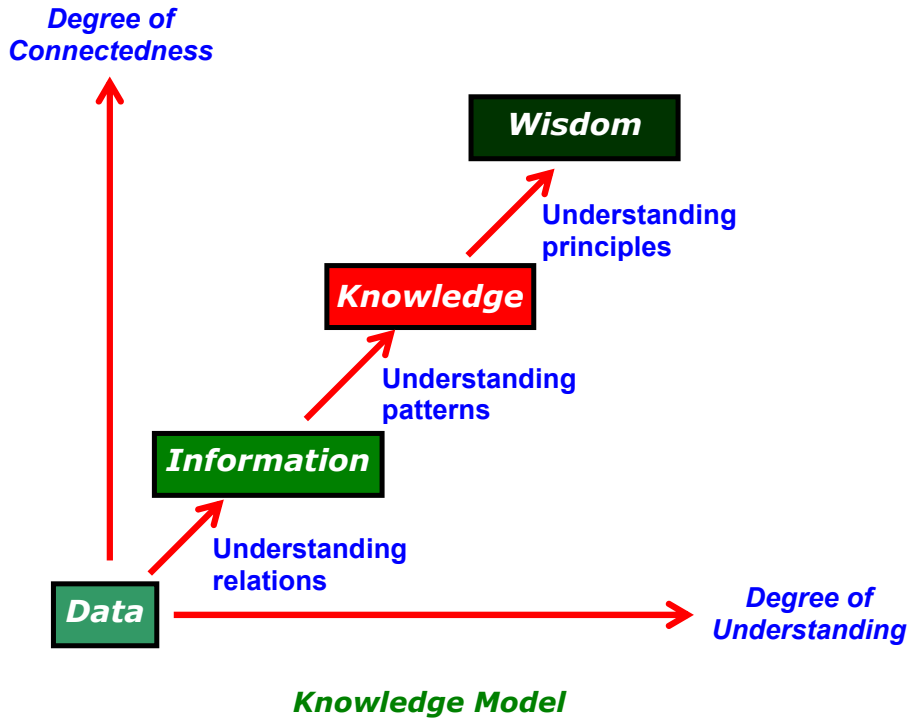
Knowledge is a collection of "facts". To manipulate these facts by a program, a suitable representation is required. A good representation facilitates problem solving.

Learning : programs learn from what the facts or behaviors can represent. Learning denotes changes in the system that are adaptive, means it enables the system to do the same task(s) more efficiently next time.

Applications of AI : problem solving, search and control strategies, speech recognition, natural language understanding, computer vision, expert systems.

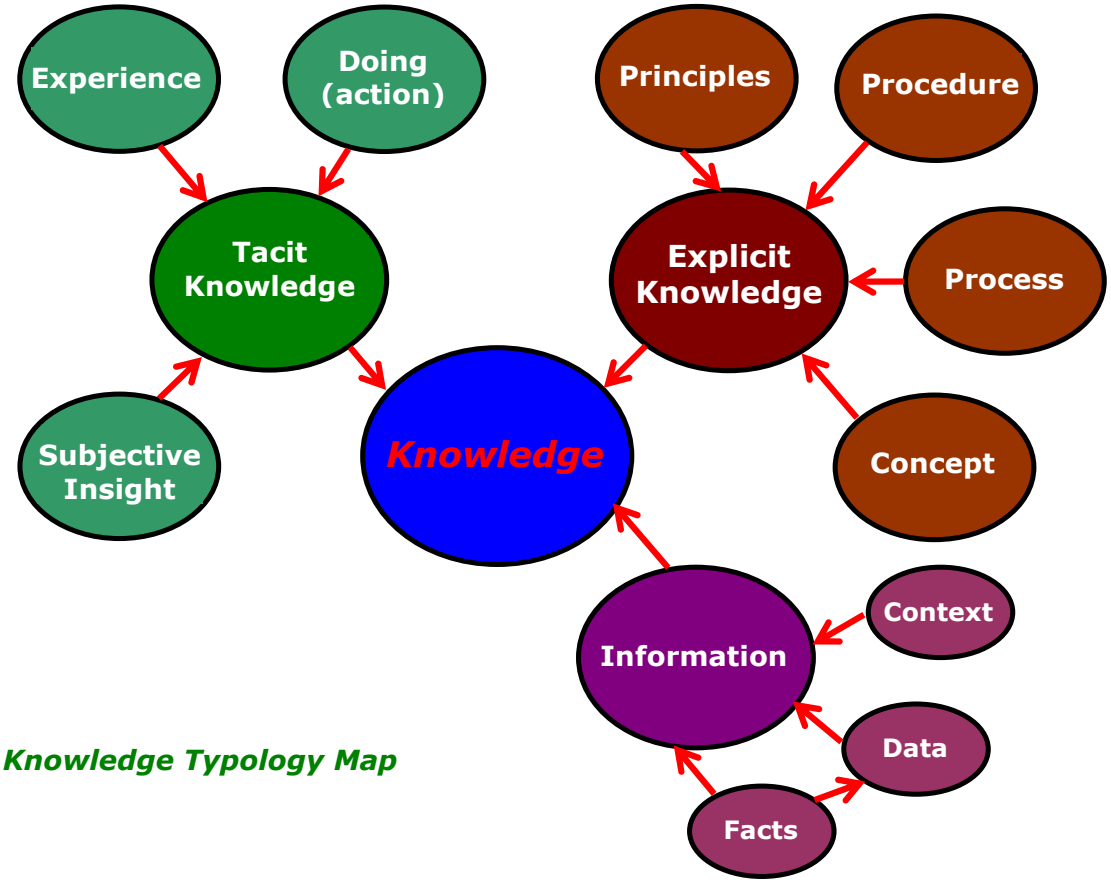
Knowledge is a progression *: Starts with data which is of limited utility. By organizing or analyzing the data, this becomes information. The interpretation or evaluation of information yield knowledge. An understanding of the principles embodied within the knowledge is wisdom.*

Knowledge Model tells that, as the degree of "connectedness" and "understanding" increase, we progress from data through information and knowledge to wisdom.



Knowledge Model

Knowledge typology map *shows that, Tacit knowledge comes from experience, action, subjective insight, and Explicit knowledge comes from principle, procedure, process, concepts, via transcribed content or artifact.*



Knowledge Typology Map

Facts are data or instance that are specific and unique.

Concepts are class of items, words, or ideas, that are known by a common name and share common features.

Processes are flow of events or activities that describe how things work rather than how to do things.

Procedures are series of step-by-step actions and decisions that result in the achievement of a task.

Principles are guidelines, rules, and parameters that govern;
principles allow to make predictions and draw implications;
principles are the basic building blocks of theoretical models (theories).

These artifacts are used in the knowledge creation process to create two types of knowledge: declarative and procedural. explained below.

Building Intelligent Communication Systems

Modern telecommunications are based on coordination and utilization of individual services, such as telephony, cellular, cable, microwave terrestrial and satellite and their integration into a seamless global network. Successful design, planning, coordination, management, and financing of global communications network require a broad understanding of these services, their costs, and the advantages and limitations.

The next generation of wireless and wired communication systems and networks have requirements for many AI and AI-related concepts, algorithms, techniques and technologies. Research groups are currently exploring and using Semantic Web languages in monitoring, learning, adaptation, and reasoning.

Note : Government institutions , corporate and academic researchers are working on a network that would configure itself, intelligently cache and route data, allow fast and reliable sharing of data, all while maintaining military-grade security. Some of these activities have featured at the "workshop on Real-Time Knowledge Processing for Wireless Network Communications" held in March 2006. Research on these and related topic are focused in the US National Science Foundation (NSF) - Global Environment for Networking Innovations (GENI) initiative.

*Just for an idea about **Intelligent Communication Systems**, here an "Intelligent Mobile Platform", the "Voice-Recognition Across Mobile-Phone", and the "Project Knowledge Based Networking" by DARPA are briefly illustrated.*

- ***Intelligent Mobile Platform : Magitti***
  (http://www.gisdevelopment.net/ezine/global/pdf/jan08/65.pdf
  http://www.gisdevelopment.net/magazine/global/2008/January/65.htm)

The mobile phone is no more a simple two-way communication device. Intelligent mobile infer our behavior and suggest appropriate lists of restaurants, stores, and events. Magitti is designed to :

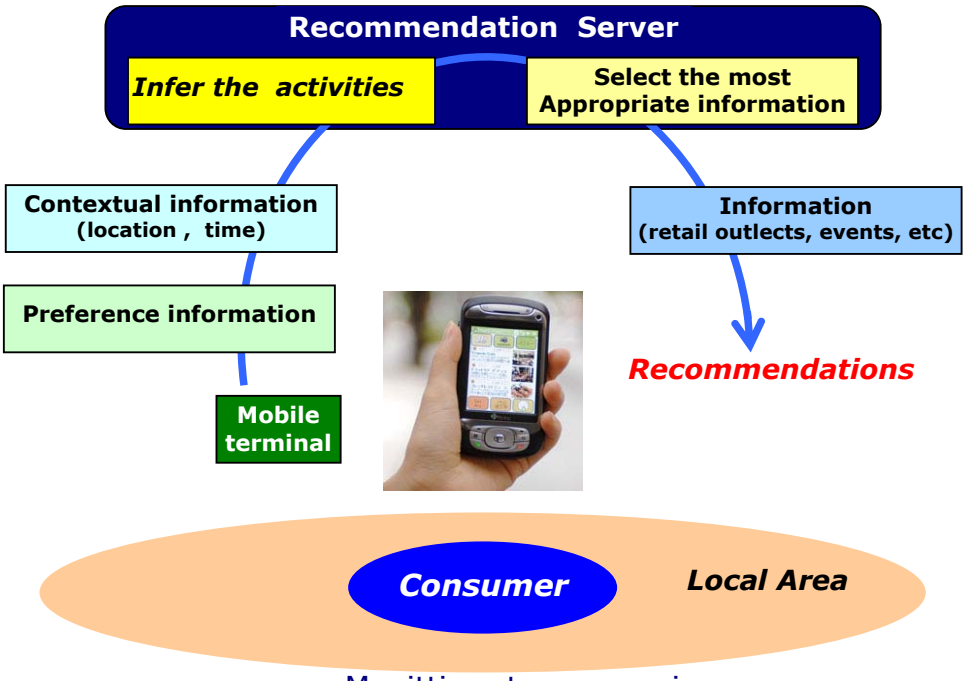
- *assist in getting "location based information*
- *suggest activities based upon the local area data, like shopping, dining, banking etc., matching the consumer's location, his behavior pattern and time of day.*

The difference between Magitti with other GPS enabled mobile applications, is the Artificial intelligence.

Magitti is intelligence personal assistant .

Magitti's specifications has not been released, but the mobile phones are becoming increasingly powerful with sensors, entertainment tools, accelerometer, GPS etc. Perhaps the AI would make more sense in short time.

Magitti technology : shown below



Magitti system over view

Dai Nippon Printing and Palo Alto Research Center have developed this context-activity-aware system. The trials are expected to take place shortly and commercial sales would start in 2009 in Japan followed by USA.

- ***Voice-Recognition across mobile-phone : Vlingo***
  (http://www.vlingo.com/ , http://www.vlingo.com/technology.html)

Mobile phones can do lots of things, but the majority never use them for more than calls and short text messages. Voice-Recognition-Correction interfaces across mobile-phone applications is coming to market to provides speech recognition.

Now you can talk to your phone and the phone understands you.

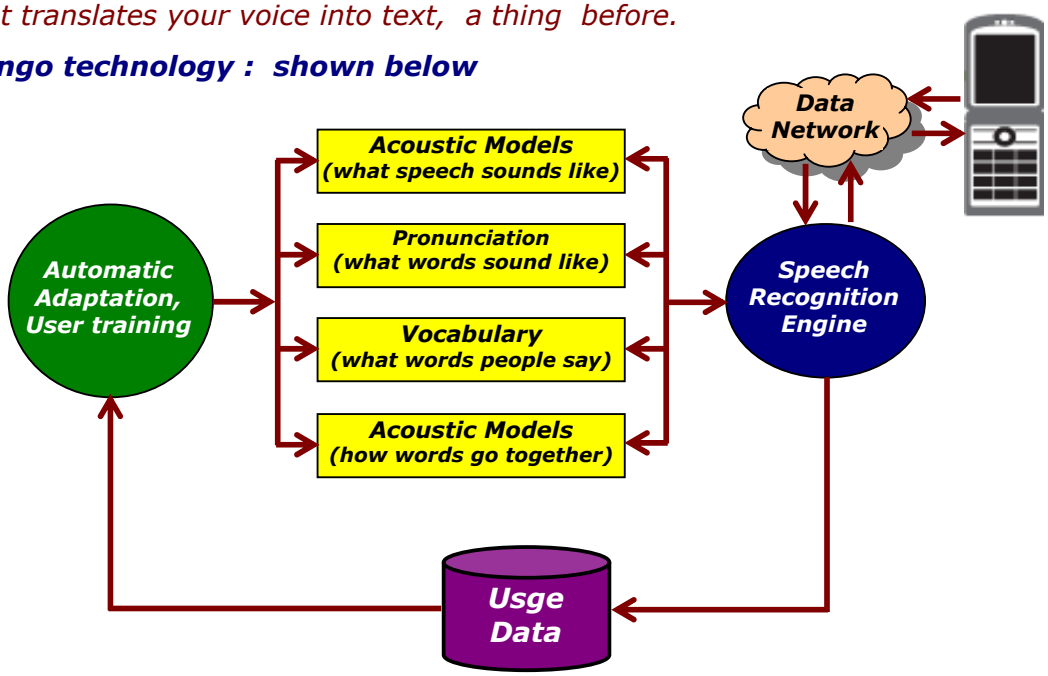
Thus, send a friend a text message without typing, just speak, verify and send, or find stuff like , e.g.,

- *say : "pizza places in Pittsburgh."*
- *Your phone figures out what you want, finds it and shows you how to get there.*
- *No tapping, no thumbs, just good old speaking.*

Vlingo

It is all possible with the technology, Vlingo software offers, that translates your voice into text, a thing before.

Vlingo technology : shown below



Hierarchical Language Model Based Speech Recognition

Vlingo takes speech, turns it into text, and provides a simple way to correct errors using the phone's navigation keys, helping the system "learn". The user's spoken words travel over a mobile internet connection for analysis on Vlingo's server, sparing the phone form the heavy computational work; the transcription appears in less than two seconds.

- ***Project Knowledge Based Networking by DARPA***

*Military research aims to develop self-configuring, secure wireless nets. Academic concepts of **Artificial Intelligence** and **Semantic Web**, combined with technologies such as the **Mobile Ad-hoc Network (MANET)**, **Cognitive Radio**, and **Peer-to-Peer networking**, provide the elements of such a network. This project by DARPA is intended for soldiers in the field.*

- *The network that would be able to configure itself, intelligently cache and route data, and allow for fast and reliable sharing of data, while maintaining military-grade security.*
- *The ideal MANET would not only choose the best paths for routing packets but would also pick the best radio frequency to use.*
- *The intelligent network would not only understand how to move data; it would also be able to understand what the data meant to users.*

■ Semantic Web :

Web is first generation of World Wide Web, contains static HTML pages. Web 2.0 is second generation of the World Wide Web, focused on the ability for people to collaborate and share information online. It is dynamic, serves applications to users and offers open communications.

Web requires a human operator, using computer systems to perform the tasks required to find, search and aggregate its information. It is impossible for a computer to do these tasks without human guidance because ***Web pages are specifically designed for human readers.***

Machine-Understandable Web information :

Semantic Web is a universal medium for data, information, and knowledge exchange. Semantic Web is presently a project: aim is to present web page data such that it is understood by computers, enable machines to search, aggregat and combine the Web's information without human operator.

Note :The Semantic Web is not a separate entity, but an evolving extension of the World Wide Web in which the semantics of information and services on the web is defined, making it possible for the web to understand and satisfy the requests of people and machines to use the web content.

Example :

"The Beatles was a popular band from Liverpool. John Lennon was a member of the Beatles. The record "Hey Jude" was recorded by the Beatles."

- *sentences like these people can understand. But how computer can ?*
- *statements are built with syntax rules. The syntax of a language defines the rules for building the language statements.*
- *how can syntax become semantic?*

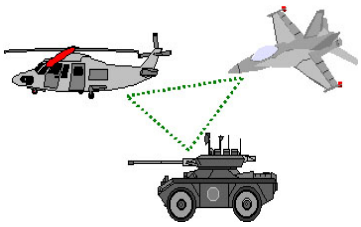
This is what the Semantic Web is - describing things in a way that computers applications can understand.

- ***Mobile Ad-hoc Network (MANET)***

The traditional Wireless mobile networks have been "Infrastructure based" in which mobile devices communicate with access points like base stations connected to the fixed network. Typical examples of this kind of wireless networks are GSM, WLL, WLAN, etc.

Approach to the next generation of wireless mobile networks are "Infrastructure less". The MANET is one such network.

A MANET is a collection of wireless nodes that can dynamically form a network to exchange information without using any existing fixed network infrastructure. This is very important because in many contexts information exchange between mobile units cannot rely on any fixed network infrastructure, but on rapid configuration of a wireless connections on-the-fly. The MANET is a self-configuring network of mobile routers and associated hosts connected by wireless links, the union of which form an arbitrary topology that may change rapidly and unpredictably.



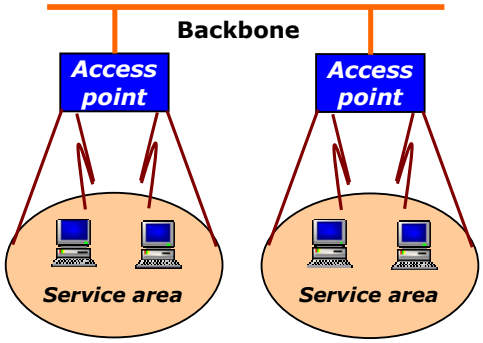
MANET concept

A mobile ad-hoc network is a collection of wireless nodes that can dynamically be set up anywhere and anytime without using any existing network infrastructure. It is an autonomous system in which mobile hosts connected by wireless links are free to move randomly and often act as routers at the same time.

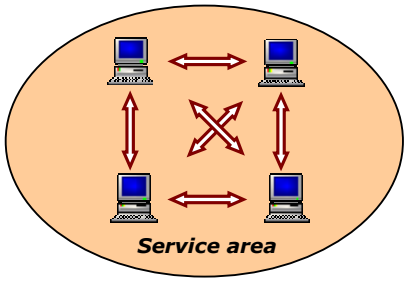
The MANET traffic includes:

- *Peer-to-Peer : between two nodes*
- *Remote-to-Remote : two nodes beyond a single hop and*
- *Dynamic Traffic : nodes are moving around.*

Below shown the examples of infrastructure and infrastructure-less ad-hoc wireless networks.



Infrastructure based wireless network



Ad-hoc wireless network

MANET features :

- *Autonomous terminal : Each mobile terminal is an autonomous node, which may function as both a host and a router.*
- *Distributed operation : There is no background network for the central control operations and management, rather distributed among the terminals. Each node acts as a relay, to implement functions, e.g., security and routing.*
- *Multi-hop routing : The routing algorithms can be single-hop and multi-hop, based on link layer attributes and routing protocols. When delivering data packets from a source to its destination out of the direct wireless transmission range, the packets are forwarded via one or more intermediate nodes.*
- *Dynamic network topology : Since nodes are mobile, the network topology may change rapidly, and unpredictably and connectivity among the terminals may vary with time. MANET adapts to the traffic and propagation conditions as well as the mobility patterns of the mobile network nodes. The mobile nodes in the network dynamically establish routing among themselves as they move about, forming their own network on the fly that may require access to a public fixed network (e.g. Internet).*
- *Fluctuating link capacity : The bit-error rates of wireless connection might be more profound in a MANET. The channel over which the terminals communicate is subject to noise, fading, and interference, and has less bandwidth than a wired network. In some scenarios, the path between any pair of users can traverse multiple wireless links and the link themselves can be heterogeneous.*
- *Light-weight terminals : The nodes are mobile devices with less CPU processing capability, small memory size, and low power storage. Such devices need optimized algorithms and mechanisms that implement the computing and communicating functions.*

MANET status :

- *As a technology for dynamic wireless networks, it has been deployed in military since 1970s.*
- *Commercial interest in such networks has recently grown due to the advances in wireless communications.*
- *A new working group for MANET has been formed, aiming to investigate and develop a framework for running IP based protocols.*
- *Research in the area of ad hoc networking is receiving attention from academic, industry, and government institutions.*

MANET applications

Wireless communication ad-hoc networking is gaining importance, where there is little or no communication infrastructure or the existing infrastructure is expensive or inconvenient to use. MANETs has diverse applications, ranging from large-scale, mobile, highly dynamic networks, to small, static networks that are constrained by power sources. Typical applications include:

- *Military battlefield : Ad-hoc networking between the soldiers, vehicles, and military information head quarters.*
- *Commercial sector : Ad-hoc networking during emergency, rescue operations for disaster relief efforts, e.g. in fire, flood, or earthquake, where existing communication is damaged. The other scenarios include e.g. ship-to-ship ad-hoc mobile communication, etc.*
- *Local level : Ad-hoc network links to instant and temporary multimedia network, using notebook/palmtop computers, to spread and share information among participants, e.g., conference or classroom, home networks where devices can communicate directly to exchange information, civilian environments like taxicab, sports stadium, boat and small aircraft.*
- *Personal Area Network (PAN) : Short-range MANET between mobile devices (e.g., PDA, laptop, and cellular phone), wired cables replaced with wireless connections, extend access to the Internet or other networks e.g. Wireless LAN (WLAN), GPRS, and UMTS. The PAN is potentially a promising application field of MANET in future.*

- ***Cognitive Radio***

The concept of the 'cognitive' radio was originated by Defense Advance Research Products Agency (DARPA) scientist, Dr. Joseph Mitola in 1999, and is the 'next step up' for software defined radios (SDR) that are emerging today, primarily in military applications.

Most commercial radios and many two-way communication devices are ***hardware-based*** *with predetermined, analog operating parameters.*

A Software Defined Radio (SDR) is a radio communication system where components that have typically been in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors. etc.) are ***implemented using software****. The SDR concept is not new. A basic SDR consists of a computer (PC), a sound card, some form of RF front end and embedded signal-processing algorithms. SDR radio can receive and transmit a different form of radio protocol just by running different software.*

Cognitive Radio *(CR), has SDR at its Root, is a smarter way to use radio frequencies. It is called cognitive radio, or smart radio, because it senses its environment and reacts to it.*

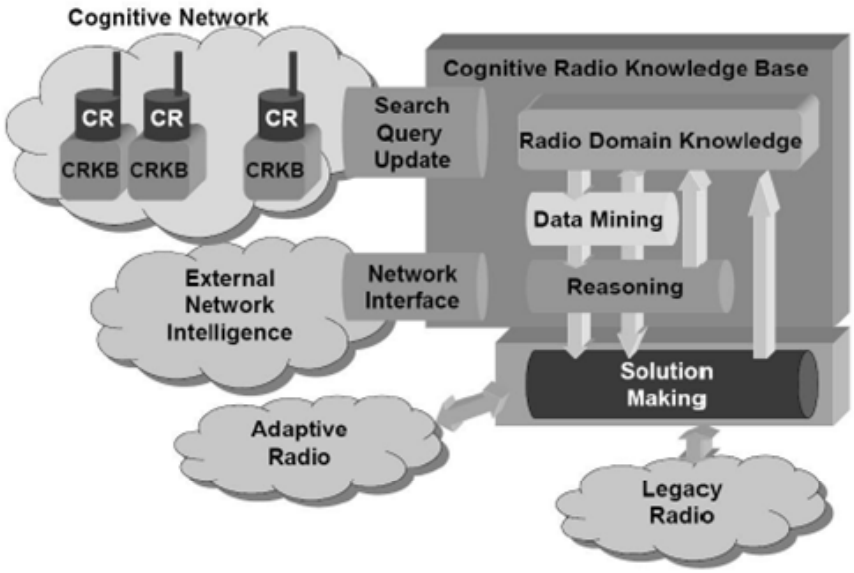
CR definition *: An intelligent communication device that is aware of its environment and application needs. It can reconfigure itself to optimize quality of service.*

The CR architecture, features, and the status are stated below.

Cognitive Radio Architecture

(http://www.sdrforum.org/SDR08/3.3-2.pdf)

The CR node functional structure is shown below.



CR functional structure as a network node

- *Cognitive engine (CE), an algorithm software package, is designed and overlaid on the radio hardware platform.*
- *CE manages radio resources to accomplish cognitive functionalities and adapts radio operation to optimize performance.*
- *CE enables a radio to provide cognitive functionalities by combining the machine learning process with radio operation.*
- *Machine learning core enables cognitive capabilities for wireless applications. Reinforced learning and evolutionary optimization are key design principles of the learning core. A two-loop cognition cycle is embedded in the learning core.*
- *Any radio with an appropriate level of re-configurability can be controlled by the CE via a platform independent radio interface. CE is not platform specific, general knowledge and learning can be applied for a variety of applications and problems.*
- *As a network node, CR can work individually or jointly on resource management and performance optimization. The CR learning structure includes recognition, reasoning and adaptation.*

CR features : CR is complete with an intelligent layer of awareness, reasoning and learning necessary to optimize performance under dynamic and unpredictable situations. Its typical features are :

- CR intelligent layer is called a cognitive engine (CE)
- CE can be applied to different reconfigurable radio platforms
- CE embeds a two-loop cognition cycle (CC) as its learning core.
- CC integrates radio environment sensing and recognition, case-based reasoning, solution making, evolutionary solution improving.
- KB, the radio knowledge database, is defined and implemented to support the reinforcement learning through the cognition cycle.
- CR solution emphasizes platform independent system architecture for various applications.
- CE algorithm framework is open-structure and modular, which can be easily reconfigured for the target problem.

CR status : A fully functional public safety cognitive radio (PSCR) node is prototyped to provide the universal interoperability. The complete PSCR node software system has been packaged for outside organizations to build prototypes and carry on field testing.

Conclusion

We live in an era of rapid change, moving towards the information / knowledge / network society. We require seamless, easy-to-use, high quality, affordable communications between people and machines, anywhere, and anytime. The creation of intelligence in machine has been a long cherished desire to replicate the functionality of the human mind. Intelligent information and communications technology (IICT), emulates and employ some aspect of human intelligence in performing a task. The IICT based systems, include sensors, computers, knowledge-based software, human-machine interfaces and other devices. The IICT enabled machines and devices anticipate requirements and deal with environments that are complex, unknown, unpredictable and bring the power of computing technology into our daily lives and business practices. Intelligent systems were first developed for use in traditional industries, such as manufacturing, mining, and more, enabling the automation of routine or dangerous tasks to improve productivity and quality. Today, intelligent systems applications exists virtually in all sectors where they deliver social as well as economic benefits.

References : *Open sources – mainly internet.*

Note : This talk is prepared, using information available from open sources, mainly internet sources, for bringing general awareness about the Influence of Artificial Intelligence on Communication systems. There is no commercial interest, what so ever, is involved. Some references, not all, are listed below.

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