Universal Knowledge Processing Systems: A Conceptual View and Architecture

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Abstract **-** *In this paper we present the architectural concepts of highly complex knowledge based system dubbed as the Universal Knowledge Processing System (UKPS) could be thought of as a Wisdom Machine (WM) capable of solving any problem simple or difficult with the help of its knowledge bases. The Universal Knowledge Processing Machine is in turn formed of several Knowledge Processing Systems (KPS) connected together through a global network The paper also discusses the key block level components which go on to make the architecture of this highly complex based system. Some of the concepts presented here are at an abstract level and needs further investigation in the cycle of evolution and development.*

1.0 Introduction

The architecture of the knowledge processing systems over the decades has changed in the philosophy of computing in organization from the mainframe-dominated, centralize computing systems to the network based distributed computing systems. Fundamental features that distinguish it from the previous systems to the distributed systems are the distribution of resources and functions among several computers of workstations that are networked together using the present day communication protocols such as TCP/IP and RISC processors. The operating systems could be UNIX, Windows NT or any other flavors of UNIX. Internet / Intranet technology has undergone lot of changes and as result of which we see it being applied to various fields. These technologies have far reached into our office and home environment. The important factor for the Intranet based Knowledge Processing Systems to be solved is real time performance and reliability of the decision based control. A brief introduction to the client-server architecture is discussed after which the model of the Universal Knowledge Processing System or Wisdom Machine is proposed. The features of this model which distinguishes it from the distributed systems are the use of the browser, wide area network (WAN), and wide area cluster of servers on the WAN and multicast communication based on IP. The Intranet based UKPS provides the basic underpinning for improved flexibility and expandability. Several of the KPS could be integrated to form the UKPS or Wisdom Machine. The architecture also enables the knowledge processing centers which contain these KPS to be rearranged as and when required.

2.0 Client/Server Architectures

The client/server software architecture is a versatile, message-based and modular infrastructure that is intended to improve usability, flexibility, interoperability, and scalability as compared to centralized, mainframe, time sharing computing. A client is a requester of services and a server is provider of services. A single machine can be both a client and a server depending on the software configuration. Commonly used client/server architectures are either two tiered or three tiered architectures.

- **Two tiered architecture**

In the two tiered architecture the client machine has the user interface and the server machine which is a powerful machine serving a number of clients at a time. The server could be providing database management services in which case the server provides stored procedures and triggers. In this case the process management is split between the user system interface environment and the database management server environment. The server maintains a connection with its client through the keep-alive messages even at time when no useful work is done and also the limitation in its flexibility to move the program functionality from one server to another are seen as limitations of the two tiered architecture systems.

- **Three tiered architecture**

In this architecture the limitations seen in two tiered architectures are overcome and middle tier is introduced in between the user system interface environment and the database management server environment. The middle tier can perform queuing, application execution, scheduling, prioritization and database staging. The middle tier can be implemented in the form of transaction processing monitors, message servers or application servers.

In addition to the computers and their operating systems, programming languages and their compilers play an important role in writing code in a simple and efficient way such that even complex programs could be developed in a reasonable amount of time with the required manpower needed for the development. With this grows the complexity of the code and software that is developed and hence different methodologies are to be adopted to design, validate and maintain the software.

3.0 Knowledge Processing System

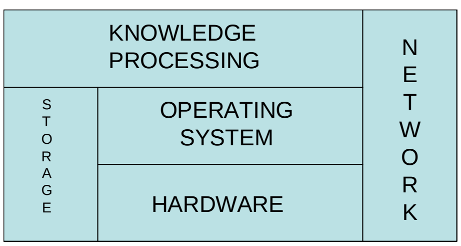

Fig. 3.0: **Basic Components of Knowledge Processing System**

A simplistic view of knowledge processing system is that it is a system which can make or provide a decision based on certain input information or query together with the knowledge base. In order to process the information and arrive at a decision these systems should be equipped with the necessary knowledge stored within it.

From an architectural perspective the basic components of such a system is as follows:

- Hardware
- Operating system
- Storage
- Network
- Knowledge processing

Figure 3.0, provides a block diagram view of how these components are assembled together to form the knowledge processing system.

The hardware component of the KPS could be a chemical, optical or silicon based platform. As the technology evolves the platforms could be based on some other technology as well. The operating systems like UNIX, Windows XP and other operating systems in the evolution path should be able to work independent of the platform technologies, storage and communication networks. In the evolution path the operating system, hardware, storage and network could change but the knowledge processing functions and data, developed and collected over a period of time should be able to function irrespective of the changes in the basic components of the KPS.

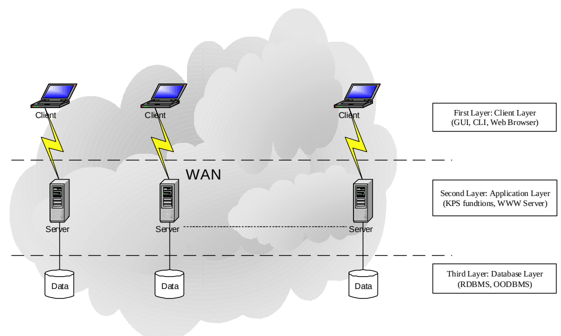

Fig. 3.1: **3 Tier Model of Knowledge Processing System**

Applying the 3 tier model to this architecture as shown in figure 3.1, applications such as monitoring function and decision control function are installed in the second layer. Data in the form of real time input is stored in the third layer. Application layer and the database layer are installed in the server. Graphical User Interfaces (GUI), Command Line Interface (CLI) or Web Browser installed in the first layer enables the operator to monitor and display pages and to control the KPS if required. To control the Knowledge Processing System an operator connects the GUI or the browser to the corresponding system, then requests to control the decision process through the pages displayed on the browser. Since the servers of the KPS could be located anywhere the operator needs to know the location of the servers. In this model an authorized operator could use the application in any KPS connected to the WAN and suitably control the decision process if necessary in a positive manner.

Using the wide area cluster architecture the servers of the KPS are separated geographically and connected through a WAN. If the server or the servers in the cluster fails then the other healthy servers back up the functions automatically. Once the failed server is brought up again the server is put back in the cluster as a healthy server thereby providing fault tolerance. Each of the KPS could have a single or multiple of these servers representing the second and the third layers.

The architecture considered here is a high performance architecture which provides high speed response of the man-machine interface. Whenever an application such as the monitoring function or the decision control function in the second layer updates the database layer, the high performance architecture distributes the updated data to the relevant KPS. Multicast communication based on IP is applied to this replication process.

4.0 Universal Knowledge Processing System or Wisdom Processing System

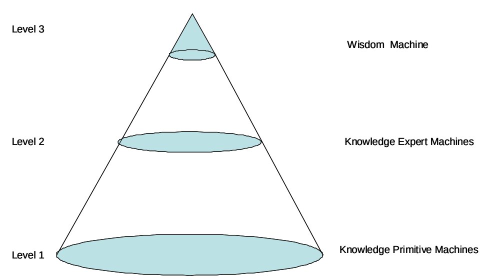

Fig. 4.0: **Wisdom Processing System Architecture**

The wisdom processing systems architecture in figure 4.0 shows the different levels of knowledge processing systems that are required to arrive at a decision or solution based upon wisdom. The systems at all these levels have the same set of basic components as shown in figure 3.0. However the knowledge contained at each of these levels together with the processing power of these systems could vary, the systems at the top being the most powerful systems in terms of computing power, storage, network bandwidth, operating systems and other capabilities and the ones at the bottom level being the least powerful systems. The systems at all these different levels are networked together either by a dedicated network or through a shared network.

Level 1: The systems at this level are knowledge primitive machines with the ability to store user entered data or data received from external sources, process data, analyze / model data, suggest or make a decision for less complex problems thus serving as a decision support system. It should also be able to compile data for higher level systems. The systems at this level have the necessary intelligence and knowledge to process the preliminary data for any given task by extracting the necessary information and sending the compiled results to the next level machines for a more thorough processing for the given task or problem.

Level 2: At this level the systems are knowledge expert machines which will act as expert systems with access to knowledge base consisting of view of experts, sets of rules and sets of relationships. It contains a database rich with information related to a specific task. Simulates an expert thought process using knowledge processing library functions and methods for logic and reasoning for the tasks to be analyzed and for the decisions to be provided based on the query or input information. On the development front it has the means of programming to enhance the knowledge base and the inference process. With this capability the level 2 machines have the ability to provide recommendations, decisions, solve complex problems, adapt to problem solutions, learn and continually refine the methods in the inference engine. Since these machines reside at a level between that of the level 1 machines and the level 3 machines they have the necessary knowledge and intelligence as how to interface with these levels. These systems also have the ability to compile data and send it to the higher levels.

Level 3: This level consists of a group of very powerful systems connected together using dedicated network. From the basic knowledge processing component perspective they are the same except that they are much more powerful in terms of the processing power, storage capabilities and network capabilities. These systems can independently solve a complex problem or get the pre-processed information compiled together from the levels below, extract the information and decide. The compiled results obtained from the different expert or experts for the same problem is taken and further analyzed by giving a certain weight to each of them. It could be possible that for the nature of the complex problem they may not be any experts so these systems are in a position to extract the partial decision by using the available expertise and arriving at a decision. During this process the level 3 systems could use some other expert system or systems or possibly the same expert systems as before by exchanging information back and between these network of systems at all levels it is quite possible to arrive at a conclusive result for a problem of such complexity. If the knowledge base does not exist for the given problem then it could be obtained by unleashing several queries to the experts which could be systems or humans, in which case the unavailable knowledge base is compiled in real time. Solving problem in this manner could introduce delays, however for time critical tasks decisions have to arrive at without any delays in which case the system will continue with the decision which would be based upon the decisions of the expert systems with the current knowledge base with a certain confidence level. Human interaction is necessary at this critical juncture either to go ahead with the decision taken or to do something different. These systems will also oversee the decision process of the systems at the levels below if the systems at level 1 and 2 are granted access to.

Although in this present architecture only three different levels are shown, in reality each of these levels could be further sub-divided in sub-levels. The systems at level 2, which are experts, could be classified in different sub-levels based on their degree of expertise and systems at level 1 could be divided into sub-levels based on their storage, processing, modeling and analysis capabilities. At level 3 we assume that all the systems are of the same degree in terms of wisdom, they may not be experts in the related area but given the information and the problem they have the necessary wisdom to come to a suitable conclusion. Since at this level there is a network of such systems, the final decision is based on the majority numbers of decisions of these systems so that a check is maintained at arriving at a wrong decision. Post processing of extracted wisdom is discussed in [1].

Since the Intranet based UKPS could be accessed from many terminals Secure Sockets Layer (SSL) should be applied to the communication between the GUI, CLI or browser and the World Wide Web (WWW) server and each of the operators should be allowed to access only predefined contents.

5.0 Methods of Reasoning

Decisions at all levels are arrived at by using different methods of reasoning such as reasoning by induction, reasoning by both deduction and prediction and logical reasoning. Inductive reasoning is usually based on observation wherein the premises of inductive arguments are bits of evidence gathered either directly or indirectly and its conclusions are tentative generalizations about groups or relationships or predictions. So with inductive reasoning, conclusions drawn based upon the premises however accurate they may seem could possibly have other conclusions as well, which is to say that the conclusion drawn is a possible one but not necessarily a reasonable one for the problem at hand, thus inductive conclusions do not follow of necessity from the premises. Nevertheless inductive reasoning helps us to start building the knowledge base with general statements and principles from what we know so far, which is the learning process.

In deductive reasoning, it generates necessary conclusions based on the premises of the arguments. The argument if it is a syllogism then it draws conclusion about the member of a group from the generalization about the group and the relationship between the member and the group and if the argument is a hypothetical chain then it draws conclusion from a general prediction and the given situation. Though deductive methods put to test the generalizations of the inductive methods it has to be adaptive so that the generalizations could be fine tuned for a specific task or problem.

Critical thought process requires both inductive and deductive reasoning, whereby by inductive methods we get to learn and formulate with certain generalizations which needs to be put to test by deductive methods so that the generalizations could be tested to see if they hold.

6.0 Applications

In this paper we present two scenarios where such a complex system would be of use. The two applications would be

- Power Outage Detection and Prevention and
- Tsunami Early Warning System

6.1 Power Outage Detection and Prevention

The power outages which have occurred in several major cities in recent times across the globe have affected trains, elevators and the normal flow of traffic and life. In some cities, water supplies were affected because water is distributed through electric pumps. Airports across the affected region experienced delays and some shut down temporarily. The outage slowed the Internet resulting due to re-routing of the internet traffic and Web sites powered from servers in affected cities were unable to respond to requests from the clients. In order to prevent such a disaster, KPS which could decide based on the factors such as overloading of the grids could be detected and analyzed with the prevention of a major power outage, by isolating the defective power center or centers which is likely to trigger the tripping of all the power grids, thus minimizing the damage caused due such an outage.

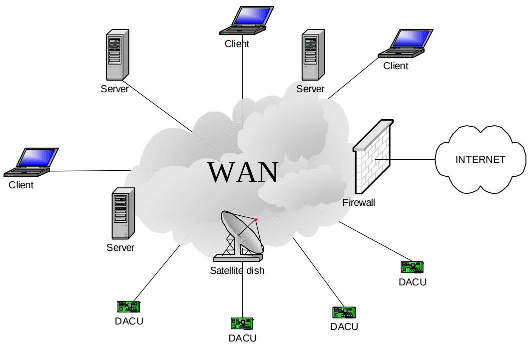

Fig. 6.1: **KPS Model for Power Outage Detection and Control**

The proposed KPS based model and architectures are presented as shown in figure 6.1. The model consists of data acquisition and control units (DACU) connected to the KPS which sends the acquired data of the power systems to the servers of the KPS in which the collected data is processed using the knowledge processing functions. The data from each power center is collected by means of a client used by the operator either manually or automatically from the DACU and sent to the KPS via the WAN. Multicast communication is used between the DACU and the KPS servers and all servers can receive data from each and every DACU. Each server and the each client are connected directly to the WAN. Browsers installed in each client enable the operator to monitor and control manually and allows access to any server which is transparent to the client. Critical functions installed in each of the KPS servers along with the incoming data are constantly backed up. The UKPS which is an intranet connects to the internet through a firewall. A satellite link is provided so that critical data is sent to another geographic location where a similar KPS set up exists and also to transmit collected data and receive control signals from KPS in another geographic location in the event of a natural calamity which could paralyze the local KPS set-up. The decision making process is at the UKPS which connects several KPS networks. In spite of all this one has to note that there is some amount of delay involved for the data to be collected by the DACU and sent to the KPS servers where the data is processed and sent further to the UKPS for the final decision to be made after it has analyzed the processed data from the other KPS. The processed data could be a partial decision taken by the local KPS or it could be that no decision is taken by the local KPS or that it could suggest a list of remedies to the problem at hand to which the UKPS would finally be the decision maker. The decision taken by the UKPS could be over-ruled in the manual mode by the operator or operators monitoring the power centers. In the auto mode the decision would be taken by the UKPS and the control signals sent to the DACU for appropriate action to be taken.

6.2 Tsunami Early Warning System

There are so many variables and uncertainty in the detection of a natural disaster that is to occur like Tsunami. In some cases we might have little or no information about the situation; in other cases the available information is so vague or incomplete. In almost all these cases the system has to operate under severe time constraints with little or no time to make a critical decision and sound an alarm about the catastrophe that is likely to occur. Variability and inevitability which results from complexity is due to the interaction of numerous independent actors. In the environment of uncertainty, complexity and variability requires sound judgment, creativity and initiative which the UKPS should be able to handle.

The Tsunami Early Warning System consists of two stages the detection stage and the dissemination stage. As part of the detection process the objective of the KPS is to detect, locate, and determine the magnitude of potentially tsunamigenic earthquakes occurring in any part of the sea floor in the world. Earthquake information is provided by seismic stations operated in different parts of the world. If the location and magnitude of an earthquake meet the known criteria for generation of a tsunami, a tsunami warning is issued to warn of an imminent tsunami hazard. The warning includes predicted tsunami arrival times at selected coastal communities within the geographic area defined by the maximum distance the tsunami could travel in a few hours. A tsunami watch with additional predicted tsunami arrival times is issued for a geographic area defined by the distance the tsunami could travel in a subsequent time period. If a significant tsunami is detected by sea-level monitoring instrumentation, the tsunami warning is extended to the other countries and regions. Sea-level (or tidal) information is provided by monitoring networks and other participating nations of the Tsunami Warning System (TWS). This effort encourages the most effective data collection, data analysis, tsunami impact assessment and warning dissemination to all TWS participants. The dissemination process consists of sending bulletins and warnings to the concerned government and emergency officials and the general public of the participating countries and even those countries that officially do not participate but is likely target of being hit by the Tsunami. A variety of communication methods are used in the process of disseminating the Tsunami warning.

The system consists of several Tsunameter Mooring Systems (TMS) positioned along the coastal line of the various countries. The TMS which consists of transducers, RF modems and a bottom pressure recording device which detects the changes in the pressure caused by the Tsunami and is sent to the surface buoy via an acoustic link which the transducers pick up and send to the satellite by means of the RF modem as shown in figure 6.2.

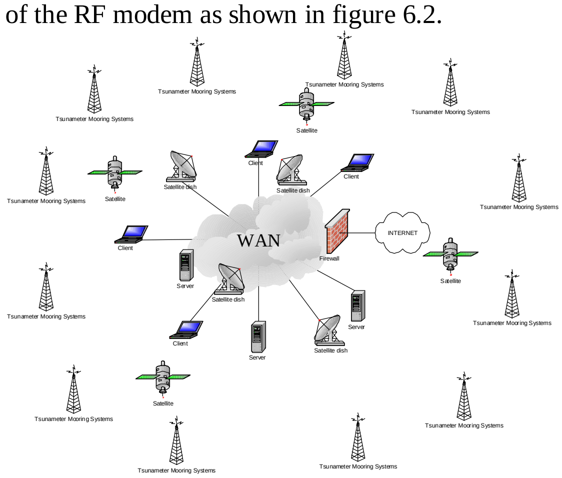

Fig. 6.2: **UKPS based Tsunami Early Warning System**

The satellite which collects the data from these TMS are sent to the processing centers where the collected data is processed and the likelihood of a Tsunami occurring will be determined and also the path and the magnitude of the Tsunami is also determined, from which the countries which would be the target of this disaster is also determined and the necessary action is then taken and disseminated to these countries or regions within a country by way of Tsunami alerts.

In above two applications discussed we clearly see a picture of chaotic environment filled with variables and unknowns.

7.0 Conclusion

In this paper a conceptual view and architecture for the Universal Knowledge Processing Systems has been presented and the applications arising from the implementation of such a system is also shown and discussed. Though the number of applications that has been presented is by no means the only ones as this could be easily extended to other complex problems as well. Many complex problems arising in day to day life which cannot ordinarily be solved by the existing computing infrastructure needs the knowledge processing systems leading to wisdom machines as presented in this paper to make decisions which are of time critical nature.

8.0 References

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