Chapter IV
Hierarchical Organization as a Facilitator of Information Management in Human Collaboration

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ABSTRACT

The purpose of this chapter is to discuss the relationship between three entities: hierarchical organization, information management and human collaboration. This relationship is composed of two parts: the first part is the relationship between the hierarchical organization and information management where the role of the hierarchical organization to facilitate the information management processes is discussed. The second part is the relationship between information management and human collaboration where the role of information management to improve human collaboration in problem solving is discussed. The information management processes are illustrated through an information management life cycle model. This model has three major stages: active, semi-active and inactive stages and has three major phases: creation, searching and utilization phases. The creation phase includes: information creation and using, information authoring and modifying and information organization and indexing. The searching phase includes: information storage and retrieving and information exchange. The utilization phase includes: information accessing and filtering processes. The arguments about the role of hierarchical organization in information management and human collaboration are also discussed. The author showed that the hierarchical organization acts as a facilitator for common information management processes which are required in team collaboration such as: information gathering, organization, retrieving, filtering, exchange, integration or fusion, display and visualization. Human collaboration models are discussed with emphasis on the team collaboration structural model which has four unique
but interdependent stages of team collaboration. These stages are: 
team knowledge construction, collaborative team problem 
solving, team consensus, and product evaluation and revision. 
Each stage has four levels: meta-cognition process which 
guides the overall problem solving process, the information 
processing tasks which is required by the team to complete each 
collaboration stage, the knowledge required to support the 
information processing tasks and the communication 
mechanisms for knowledge building and information processing. 
The author focused on the role of information management to 
improve human collaboration across the four collaboration 
stages of the team collaboration structural model. He showed 
that the hierarchical organization is more efficient for 
information management processes and team collaboration 
rather than other alternative organizations such as flat, linear 
and network organizations.

INTRODUCTION

It is widely observed that human collaboration is the true competitive 
advantage for the new era. Merriam Webster’s dictionary defines 
collaboration as working jointly with others or together especially in 
an intellectual endeavor. Collaboration is seen as a good work practice 
because it should, by definition, involve share workload, multiple 
perspectives provided by diverse expertise, enhance creativity, 
innovation, and higher product reliability, creation of knowledge and 
information access and exchange. Collaboration and teamwork are 
closely coupled activities in which team members work together to 
produce a product, solve a problem or carry out an action (David N., 
2002). Effective partnerships improve human interactions to create 
more efficient and effective collaboration where partners in human 
collaboration attempt to reach shared understanding or common 
ground (Scott, Mark, XiaoQi, & J. Geoffrey, 2008)). Common ground 
refers to the set of mutual knowledge, shared beliefs and assumptions 
that collaborators have. This process of establishing shared understanding or grounding involves 
communication using a large amount of information. According to Schrage (1995) people’s collaborative 
efforts with different skills are required to create innovative solutions and products.

To better understand and improve the effectiveness of team collaboration there is a need to better 
understand cognitive processes employed when collaborating to solve high stakes problems that may 
be characterized with time compression, supported by uncertain and open source information. This 
can be achieved by studying the process by which team members may interpret data to develop information, 
build shared understanding that informs decisions, and collaborate to ensure that information and 
knowledge are shared in support of synchronized action to take decisions. Cognitive collaboration 
models based on information management help collaborators to attain common situational awareness 
among multidisciplinary, distributed team members engaged in collaboration for issue resolution or 
decision making. It examines the cognitive aspects of joint analysis or problem solving for the purpose 
of attaining shared understanding sufficient to achieve situational awareness for decision making or 
creation of a product (Office of Naval Research, 2008). Information management processes such as 
collection, retrieval, exchange, fusion and display of information help to attain shared understanding of a 
situation at both the individual and team levels. The shared understanding of a situation is affected by 
the type of collaboration environment which can be one of the following:

1. **Distributed environment:** Which is an open standard agent-based infrastructure of communications, 
information processing, decision support, knowledge processing and resource management
services which can be configured to enable information sharing to support team collaboration (William, 2003). It interconnects remotely and temporally participants, computational resources and databases to seamlessly interoperate, gracefully enter and exit the collaboration for the purpose of developing a product or other action related to decision support in the organization (William, 1997). A distributed collaborative environment supports both single individuals and collaborating groups by managing and distributing virtual workspaces (Vance & William, 1997). These virtual workspaces contain the necessary information visualization and resource management tools each user needs to contribute to decisions throughout the life cycle.

2. **Asynchronous environment**: Which is a distributed collaboration team where members and components can be at any location and they can connect from any computer with a view independent from the connection point. No component is responsible of coordinating other components and no component is the only holder of specific information. Members of a group decide freely which actions to perform, which resources and services provide and when will be connected or disconnected. A group has a capability to continue operating with some malfunctioning or not available component. Replication of objects, resources or services can be used to improve availability and quality of service. It allows information exchange where information belonging to a group such as events, objects, and presence of information….etc. can be used by several applications. It maintains information security by a selective and limited access to the shared information and by identity authentication of information user (Joan, Leandro, & Thanasis, 2004).

3. **Culturally diverse**: Culture is obviously a source of variance in the human behavior. Therefore, a culturally heterogeneous group would be expected to display types of behavior and interactions that are different from those displayed by a culturally homogeneous group. The impact of cultural heterogeneity on group performance might ultimately result in performance outcomes that are different from those generated by a culturally homogeneous group (Imad, Souren, Peter, & Priya, 2002). Teams composed of members with homogeneous backgrounds find collaboration to be much easier than heterogeneous teams; however, heterogeneous teams eventually make decisions that are of higher quality than those of homogeneous teams.

4. **Heterogeneous knowledge**: Knowledge can be derived from different information resources such as text, maps, images and videos. Integration of these resources using knowledge management will facilitate a single query traversing transparently all knowledge repositories and related databases, regardless of their physical location. Knowledge management hierarchical organization consists of a number of layers including: knowledge portal, raw data, data transformation, knowledge discovery repository, and knowledge entry and analysis tools (Sokol, 2002). A knowledge portal is used as a convenient starting point for team members to begin their quest to enter, find and access knowledge.

5. **Unique roles**: Assigning separate roles to team members increases the scope of group collaboration. Boredom is reduced by differentiating the roles of individuals. Also, accountability can be determined by how well a team member performs particular roles.

6. **Rotating team members**: In order to use team’s limited time most efficiently and to improve collaboration and participation by all members, many teams assign roles that can be rotated among the members. Rotation may be by volunteering, alphabetical order assignment, or any other agreed upon by the group (Maryland Coalition for Inclusive Education, 1999).

7. **Common organization**: Which may be hierarchical or flat, a hierarchical organization is structured in a way such that every entity in the organization, except one, is subordinate to a single other entity.
Flat organizations emphasize a decentralized approach to management that encourages well trained employees involvement in making decisions rather than supervised by many layers of management and to become more productive. The purpose of this structure is to create independent small businesses or enterprises that can rapidly respond to customers’ needs or changes in the business environment where comments and feedback information reach all personnel involved in decisions more quickly. Supervisor tends to have a more personal relationship with his or her employees with few or no intervening middle management. (Gemmy, 2002). In hierarchical organization it is important to improve how collaborators interact on the highest, medium and low levels. Such human collaboration largely depends on how people manage information, relationships and define their goals and expectations. At lower management, people share information in small groups through informal communications and social relationships. At middle management, actors design and use processes and systems to convert informal information into codified and structured information in order to routinize repeated behaviors, transactions and information processing sequences. At upper management, highly codified and regularized information flows are produced through the enactment of property rights, laws, regulations, contracts and other overarching formal rule systems. Due to the interactions among these three levels, when information flow changes at one level the other two levels are typically affected (Fountain, 2007). User requests within working groups can be organized into a hierarchy that represents an increasingly specialized range of information topics as a query goes down the hierarchy (Wensheng; Vellaikal; Son, 2001). It establishes a logical flow of collaboration stream between interest groups. After the problem has been identified the team must decide which steps to use in solving the problem. Planning activities provide coherency, coordination and efficiency it involves dividing the problem into sub-problems. The work may be decomposed so that team members can easily work independently, or may be partitioned into interdependent tasks. Team members may work in different locations great distances apart, such as in online collaboration, or work in the same building such as in distributed collaboration. People in such collaboration environments can often meet together, or work separately, with each member in the group performing his task at his convenience and rarely engaging in synchronous conversations with others (David N., 2002). Governments seeking to share intelligence information often create hierarchical relationships to manage risks that partners will defect (James, 2007). Hierarchy organization reassures that subordinate partners will comply with their agreement to cooperate in three ways (Williamson, 1985):

1. Hierarchy gives the dominant power the right to interpret the agreement, which minimizes the subordinate’s opportunities to exploit ambiguities and unexpected developments.
2. Hierarchy allows the dominant party to create and maintain oversight mechanisms to ensure the subordinate’s compliance with the terms of their intelligence sharing agreement.
3. The acceptance of a hierarchy relationship by a subordinate partner implies that it gives the dominant power the right to legitimately punish the defective party without the right to retaliate.

Hierarchical organizations are most useful to participants when there are substantial benefits from cooperation. Hierarchy makes it easier for participants to capture joint benefits of information sharing which increases with the frequency the participants exchange information and the range of issues their agreement includes (James, 2007). Information plays an important role in people or government interaction within their hierarchical organization. Information is one of the chief inputs of each working group
activity and it is vitally important to be stored, indexed and accessed effectively. Information is a knowledge derived from study, experience or instructions. It comes in a wide variety of types, for example it could be email messages, blogs, wikis, rules or instructions, photographs, documents, presentations, databases, charts, graphs, plans, audio files, video files or an order in an online transaction processing system. The extent of collected and generated information and its technical nature is important in the process of organizing, exchanging and providing equitable access to information. Information management is essentially required for the management requirements of internally produced or externally collected information. The main concern of an efficient information management system is to provide the right information to the right people at the right time. In doing so, it is important to understand current practices related to information management. It is concerned with every thing that happens to information during its life time, this include gathering information from heterogeneous resources and transform them into a unified form for the user to issue a single query that can be transparently traverse all knowledge repositories, facilitate information retrieval, display information in an easy to understand form, facilitate information exchange to help collaborators attaining a shared understanding and maintaining information security. Information management life cycle models break the life cycle of information that moves through into phases and identifying the most pertinent issues that influence how information should be managed during each phase (JISC Infonet Service, 2007). This will help work teams to identify information volumes and growth rates, its strength, any gaps and will help to organize where they are starting from. Team members in collaboration should represent a mix of information practitioner communities such as information management, records management, web management, libraries, knowledge management and information technology as well as the technical units of the organization. In the light of this, our objectives are to answer the following questions:

1. As information is hierarchically structured in nature, it is interesting to discuss how hierarchical organization facilitates information management processes?
2. Why the hierarchical organization is better than other alternative organizations such as flat, linear and network organizations for information management?
3. As human collaboration depends on information it is interesting to discuss how information management improves human collaboration?

This chapter provides the answer for these questions.

**BACKGROUND**

The relationship between hierarchical organizations and information management and its impact on human collaboration can be represented using a composite abstract relationship which can be depicted using Figure 1. In the next subsections, we will define each part of this relationship and discuss its importance.

**Information Management**

Information is one of the most vital, strategic assets of any organization. Information may be formal or informal; formal information includes statistical and management reports while informal information
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includes team discussions, experience, education, common sense, intuition and knowledge of organization’s internal and external environments. Properly organized and maintained records and information—in either paper or electronic formats—is vital to enterprises of all sizes and types whether business is done locally or globally. Reliable, complete, timely, accurate, up-to-date and can be integrated information is required in order for managers to make well-informed management decisions in their organizations and to determine whether the organization is meeting its objectives, whether resources are being used efficiently and appropriately, and ultimately whether the organization is on the right path to achieve its goals. Otherwise, managers will not be able to make decisions at the right time that ensure the beneficiary of their organizations.

Information management programs are typically tied to organizational objectives such as improving performance, gaining competitive advantages, innovation, developmental processes, and the general development of collaborative practices. Therefore, an organization requires the ability to identify, organize, maintain and access required information by everyone who needs it, in a timely manner, and then properly disposing it in accordance to appropriate rules. That is the reason why an organization needs an efficient information life cycle management. An information life cycle management can be defined as a combination of processes and technologies that determines how information flows through an organization. It can also be defined as a policy based approach to managing the flow of an information system’s data through its life cycle from creation and initial storage to the time when it becomes obsolete and is deleted. (Roger R., Gareth F., & David S., 2006). Information is organized according to specified policies:

1. As a rule, newer information and more frequently accessed information, is stored on faster, but more expensive storage media, while less critical information is stored on cheaper, but slower media.

2. Hierarchical storage management represents different types of storage media such as redundant array of independent disks systems, optical storage, or tapes. Each type representing a different level of cost and speed of retrieval when access is needed. The information technology manager can establish and state guidelines for how often different kinds of files are to be copied to a backup storage device.

Before we discuss the information life cycle management model there are some principles and requirements that should be considered while an organization is setting its information management policy and guidelines. These principles are (British Columbia Province, 2003):

Figure 1. Composite abstract relationship

![Diagram](attachment:attachment.png)
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1. Information is created and managed in a way that ensures completeness, reliability and authenticity.
2. Information is identified and retrieved.
3. Information can be exchanged.
4. Information is maintained and stored securely.
5. Information is retained long enough to meet all organization’s requirements, and permanent, archival values are identified.
6. Information is disposed of securely according to retention schedules, policies and procedures.
7. Information should be managed as an asset rather than a liability and development and establishing the channels through which information can flow.

The requirements for an efficient information life cycle management are:

1. Long term and short term information needs should be determined and schedule its records accordingly.
2. The context of electronic records such as the nature of the software, hardware, links to records in other formats etc is required.
3. An organization should determine the final disposition of its information.
4. All information records should be identified, classified according to their function and their retention period is established.
5. Improving information flow through explicit communication between individuals and external groups.

Information Life Cycle Management Model

Information may be accessed at three stages: before, during or after information related activities. Some people argue that there is a life cycle to information use starting with capture or creation, moving on to use and reuse with the ultimate goal of enriching an organization’s or work team capability. Conversely, some people would state that such a life cycle view is too linear in nature and reflects an information centric view.

There are several models to describe the information life cycle. Figure 2 shows an information life cycle management model (Borgman, Bates, Cloonan, Efthimiadis, Gilliland-Swetland, Kafai, Leazer, & Maddox, 1996) which has three major stages:

1. The active stage which includes information creation, authoring and modification, organization and indexing. If the life time of an information topic is extended or an information topic is created through data mining, this information topic is transferred to the active stage.
2. The semi-active stage which includes storing, retrieval and distribution of information.
3. The inactive stage which includes information disposal and discarding. Less frequently accessed records may be considered for relocation to an inactive stage until they have their assigned retention period.
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The model has three major phases:

1. **Creation phase which includes the following information processes:**
   a. **Creation and using:** It deals with topics from their point of origination. This could include their creation by a member of an organization at varying levels or receipt of information from external sources using gathering tools. It includes sensors, correspondence, forms, reports, drawings, computer input / output or other resources.
   b. **Authoring and modifying:** Where information is produced or modified internally.
   c. **Organization and indexing:** In a manner that allows rapid and effective access for both individuals and work groups for knowledge building and understanding. It is actually the process of arranging information in a predetermined sequence and creating a system to manage it for its useful existence within an organization. Failure to establish an effective method for information organization makes its retrieval and use nearly impossible.

Information in this phase is in the active stage.

2. **Searching phase which includes the following information processes:**
   a. **Storing and retrieving:** Efficient structures are required for storing information across an organization, to make it easy to overcome the semantic heterogeneity between information resources and keep it over time. Retrieving is the process of responding to requests, retrieval from files and providing access to authorized users to have access to the information. Information is tracked by the use of tracking information to ensure it is returned or available to others who may need access to it.
   b. **Distribution or exchange:** Which is the process of managing the information once it has been created or received. This includes both internal and external distribution, as produced information becomes a topic of a transaction with others.

In this phase, information is in semi-active stage.

3. **Utilization phase:** It includes information accessing and filtering. Information can be accessed by some particular users or agents from a larger information source or stream of information while filters acts as mediators between the information sources and their end users.

Information in this phase is in the active stage.

However, we suggest adding to this model the fusion or integration of information process which is the merging of information from different resources with different conceptual, contextual and typographical representations. This process is included in the utilization phase and information will be in the active stage. An organization must ensure the identification and preservation of permanently valuable records and the destruction of all other records in a timely, secure and environmentally sound manner (British Columbia Province, 2003). If the information has met all of its need and is no longer considered to be valuable, it should be disposed of by means appropriate for the content. This may include ensuring that others cannot obtain access to outdated or obsolete information as well as measures for protection privacy and confidentiality. Less frequently accessed information is assigned to an inactive stage until they have met their assigned retention period. Retention periods are based on retention schedule, business needs, and potential historic, intrinsic or enduring value of information. Retention schedule is based on research of the regulatory, statutory and legal requirements for management of information for the industry in which the organization operates. Retention periods may be indefinite, 25 years or longer for information that is identified to have a continuing value. This information should
be efficiently archived using persistent identifiers for the items to ensure it’s persistently accessible for the length of time they are retained (Warwick, Colin, & Julie, 2001). Policies and procedures must be established for the periodic conversion and migration of information stored electronically to ensure it remains accessible for its required retention periods.

Hierarchical Organization

The hierarchical organization is made up of organizational units it refers to how people and tasks are grouped together. The hierarchy includes an artificial organizational entity called a root at the top. All other organizational entities are descendents of this root. Under the root all nodes of the hierarchy do not need to have fixed semantics. This means that you can construct your hierarchy using a mix of sub-organizations and units. One of the major strengths of a hierarchical structure is that people are familiar with it. From universities to companies to government, people can find a hierarchical structure used to facilitate the workflow of the organization (Indratmo, & Julita, 2008).

All information is hierarchy in one way or another, without links between random facts we have no method to expand our understanding of a subject. Hierarchy helps users understand an information collection better where information items relating to one another can be logically structured, and their

Figure 2. Information life cycle model (Borgman, Bates, Cloonan, Efthimiadis, Gilliland-Swetland, Kafai, Leazer, & Maddox, 1996. Used with permission)

NOTE: The outer ring indicates the life cycle stages (active, semi-active, and inactive) for a given type of information artifact (such as business records, artworks, documents, or scientific data). The stages are superimposed on six types of information uses or processes (shaded circle). The cycle has three major phases: information creation, searching, and utilization. The alignment of the cycle stages with the steps of information handling and process phases may vary according to the particular social or institutional context.
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relationships are explicitly captured. So, people tend to organize information items based on the task relating to the items (Barreau, 1995; Kwasnik, 1989, 1991). For example, we can't learn about a new topic, without grouping together what we know about that topic in a hierarchical structure which provides a means to find relevant information. Organizing information items hierarchically is an intuitive and familiar process it is currently the predominant way to organize information items where a node in a tree represents an information item or collection of items. A hierarchical structure facilitates information search and retrieval by enabling users to reduce a search space and to eliminate any ambiguity of a term which can refer to different contexts (Indratmo, & Julita, 2008). Therefore, hierarchies are a useful meta-index to large collections of related but individually self-contained articles or information. Good examples are that people deal with a hierarchy classification scheme while looking for books in libraries or information topics in an encyclopedia, or in statutes or laws of a nation or region. Many software systems such as file systems and email clients use the hierarchical organization and allow users to create folders and subfolders to organize files to facilitate information classification, management and retrieval. Hierarchies can act as a task manager where nodes reflect the command and control relationship between them. Parent nodes send tasking information and control commands to their child nodes. Depending on the situation, complex tasks are decomposed into subtasks distributed among child nodes. Nodes routinely update their parents with feedback information such as the results of their operation, reports on failures or success, updates on their capability status. The practice of using hierarchies as an aid to task management leads to the idea of structure reuse where users can use a copy of the hierarchy structure of a project if they have another project with similar tasks (Boardman, Spence, & Sasse, 2003; Jones, Phuwanartnilrak, Gill, & Bruce, 2005). Figure 3 shows the hierarchical organization of a project structure where goals are set at the top and the project is divided into tasks. These tasks are assigned to work teams where subtasks are divided between participants who are engaged in an activity towards common objective. They have their own goals, actions, knowledge, organizational rules and structure. However, they cooperate with each other to facilitate achieving common objective.

Despite the advantages of the hierarchical structures (Lansdale, 1988; Mander, Salomon, Wong, 1992; Ravasio, 2004; Karger, & Jones, 2006; Whittaker, & Sidner, 1996; Malone, Yates, & Benjamin, 1987; Lopez, 2002) argue that a hierarchical structure has some drawbacks:

**Figure 3. Hierarchical organization of a project**
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1. The traditional hierarchical topologies frequently used by companies and organizations, are poorly designed in terms of efficiency. As the information is an appropriate measurement of centrality, this kind of topology is so attractive for leaders, because it helps the individual aim of monopolizing as much information as possible within the network. The global influence each actor has within the network is completely determined by the hierarchical level occupied (Almendral, A., López, L., Mendes, F., & Sanjuán, 2003). We will address this disadvantage later in this chapter.

2. Creating a hierarchy and classifying information accordingly is a heavy weight cognitive activity. This difficulty especially applies to knowledge workers such as analysts and researchers, who have unstructured and dynamic tasks who have to deal with ever changing work contexts and sometimes consider filing documents unimportant (Kidd, 1994). When adding an information item to a hierarchical organization, it is put into a class that is appropriate at that time. When goals and work contexts change the created hierarchies may become outdated and require a lot of time and efforts to re-organize. Furthermore, since knowledge workers handle multiple tasks concurrently, they may find information which can be put under more than one collection in the hierarchy, making it even more difficult to choose in which collection they should put them (Indratmo, & Julita, 2008). Although, people can overcome this problem by creating multiple copies of a document, they tend to put a document into a single collection only.

3. Relevant information can be gathered from different sources using different information gathering tools each of which maintains its own hierarchical organization, being unable to collect this information into a single hierarchy is known to be information fragmentation. Information fragmentation leads to repeated efforts to organize different types of information items (Bergman, Beyth-Marom, & Nachmias, 2006; Boardman, Spence, & Sasse, 2003). Consequently, users have to consult various storage locations to retrieve needed information, and it is hard to maintain consistency in overlapping hierarchies.

4. Other organization structures are available and some are gaining popularity especially on the web:

   1. Flat organization: It has recently gained popularity where tags or attributes are assigned to information items. These tags are used to group or retrieve the information items, providing associative access to the items (Dourish, Edwards, LaMarca, & Salisbury, 1999; Gifford, 1991; Gopal, & Manber, 1999). This approach is known as tagging. The tagging approach provides flexibility in organizing information items where we can put information items under more than one collection by assigning them multiple tags this facilitates the grouping and regrouping of information items. The favorite applications for the tagging approach remains in the web environment where users manage and assign tags to their shared collections on the web. Although, the tagging approach support information exchange on the web where these systems share user defined tags with all users and enable users to find other people who share the same items, the tagging approach does not support feedback information which is essential to control the flow of information between organization staff at different levels nor it supports information filtering as in the hierarchical organization where a user can be flooded with a large amount of useless information. Classification of documents such as videos and images are problematic as it depends mainly on manual annotations and users may differ in their annotations. Also, as the collection grows manual annotation becomes a problem (Indratmo & Julita, 2008). Creating tools for supporting manual annotations is one possible solution to this problem (Gemmell, 2002). Another approach to annotating infor-
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Information items is by using context analysis (Soules, & Gagner, 2003). The tagging approach does not support information security because it makes the information available to all users. Consistency is guaranteed with the hierarchical organization while it is a major problem with the tagging approach due to the freedom to associate multiple tags with an information item. This inconsistency prevents users from retrieving all relevant items in a collection at once. The hierarchical organization can support an efficient retrieval process by decomposing the retrieval process hierarchically into successive steps each of which involves decisions about only a few major alternatives. This is not available for the tagging approach which depends mainly on the flat organization.

2. **Linear organization:** In this organization information items are arranged in a list on certain order, the location of an item in the list is determined according to a particular attribute used to compare the item with other items. Alphabetical, frequency of use, priority, contextual and temporal information are among the attributes used to sort a collection of information. A sorted list of information items significantly helps the users adding new information item to the list and significantly improves the retrieval process. However, when a sorted list becomes too long it becomes difficult to manage where traversing the list to find a specific item is not easy. The hierarchical organization is used to decompose a list into sub-lists containing only subsets of the sorted information in the main list. Another weakness of a linear organization is that it shows only a single dimension of information. When a collection is sorted alphabetically, the chronological order is lost and vice versa. Moreover, unlike a hierarchical structure, a linear structure does not capture semantic relationships between information items explicitly. To overcome this limitation of the linear organization users generally integrate the linear organization with hierarchical organization instead of replacing it (Indratmo, & Julita, 2008).

3. **Network organization:** It is a generalized case of hierarchical organization, where information items can be linked to one another arbitrarily without any constraints. In recent years studies have shown that networks also show a hierarchical organization where vertices are divided into groups that are further divided into sub groups and so on. In many cases these groups are found to correspond to known functional units. The knowledge of hierarchical structure can be used to predict missing connections in partly known networks with high accuracy, and for more general network structures than competing techniques (Aaron, C., Cristopher, M. & Newman, M., May 2008). Aaron (2008) suggests that hierarchy is a central organizing principle of a complex networks, capable of offering insight into many network phenomena. One of the major drawbacks of network organization is that it is less structured than other organizational structures this makes it inefficient to get an overview of the information and to navigating the network in a search of an information item.

4. Shrideep, Geoffrey & Harshawardhan (in press) argued that organizing information topics hierarchically has some disadvantages which include:
   1. A parent topic has no control over either breadth, depth or the number of child topics within the topic hierarchy.
   2. The topic string itself reveals the hierarchy of the topics. It is thus possible to launch denial of service attacks by simply flooding the system with messages to topics within the hierarchy.
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3. Since no one really owns topics or enforces hierarchies, it is generally quite difficult to discover the structure of the topic hierarchy. This also results in the inability to enforce who would be authorized to discover such information. We will also address Shrideeps's argument later in this chapter.

To overcome the limitations of the hierarchical structures (Dourish, Edwards, LaMarca, & Salisbury, 1999; Karger & Quan, 2004) extended the notion of a hierarchical structure as follows:

1. An information item can belong to multiple collections.
2. The concept of flexible collections allows users to put different types of information items such as group relevant files, email messages, appointments and web bookmarks together with other types of information into a single collection.

In this way, information organization is abstracted from the applications that produce and manage the items and users can organize their items in a more logical and meaningful way (Kaptelinin, 2003). This principle reduces the need to maintain multiple hierarchies in various information gathering tools, alleviating fragmentation on a desktop (Indratmo, & Julita, 2008). Robin & Theodosis (1997) proposed the approach of fuzzy decision tree algorithms, to maintain a large number of classes where an information item can belong to more than one collection with different degrees of membership while minimizing the time for making the final decision by a series of small local decisions. In fact, very often it takes only $O(\log n)$ time to reach one of the $n$ possible classes, since a tree of $n$ leaves usually has depth of $\log n$.

Human Collaboration

Improving communications tools for people in all areas of an organization encourage collaboration which help to save time, reduce duplication of work, and speed decisions that could translate to more benefits. Collaboration introduces the concept of individuals coming together to create something new, commonly a new process (Anne, 2008). By definition, collaboration is the interaction between team members with the intent of creating a shared understanding that none had previously possessed or could have come to on their own (Scharge, 1995). Alberts, Garstka, Hayes, & Signori (2001) define collaboration as actors actively sharing data, information, knowledge, perceptions, or concepts when they are working together toward a common purpose and how they might achieve that purpose efficiently or effectively. Andriessen (2003) describe the term collaborative work as the situations where two or more people act together to achieve a common goal, but the actual extent of togetherness can vary substantially. When people work together toward a joint goal, they can accomplish something larger, greater, and with more impact than something done in isolation. The social need for collaboration can be seen as a consequence of two phenomena:

1. The world is becoming increasingly complex,
2. This complexity requires that people cultivate specialties and then collaborate.

There must not only be trust and integrity as a foundation, but the parties need to understand the perspectives of the other collaborators’ self interests. This understanding suggests a greater depth of involvement between collaborators. It is not only exchanging information but developing a sense of situ-
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Effective collaboration refers to the exchange of information, critical discussion, and insight within the team. Teams must process information both individually and collectively (Ickes, & Gonzalez, 1994). Once the team members start to interact, they use transitive memory to share and critique information among the team members (Wegner, 1987; Wegner, 1995). Some degree of information exchange must occur in order for the team to operate successfully (Hinsz, Tinadle, & Vollrath 1997). To help team collaboration, information exchange is a focal point which can be done by giving team members secure access to company information through the organization’s website or Intranet. According to (Hinton, Botelho, & Suchman 1998) there are three collaborative principles for effective collaboration:

1. Building and maintaining relationships is an active process requiring attention and effort.
2. One must strive to understand the perspective of others and one’s own to be an effective partner.
3. Shared decision making is the ultimate hallmark of partnership, enhancing motivation and consolidating mutual commitment.

These principles are consistent with (Weaver, & Farrell, 1997) use of the acronym TARGET to describe the characteristics of collaboration and partnerships. These characteristics include: Truth, Accountability, Respect, Growth, Empowerment and Trust. TARGET components can be used to measure the effectiveness of collaborative relationships, regardless of whether these relationships are between individuals and groups, administrators and employees or interdisciplinary colleagues. Human collaborations are characterized with three features which are (Blake, & Cabri, 2003):

1. **Negotiation:** It uses information exchange to reach shared situation awareness between collaborators.
2. **Rules:** By defining rules we control collaborators’ behaviors. Rules can be mandatory such as constraints or expected such as norms.
3. **Roles:** The main advantage of a role based approach is the separation of concerns, but it leads also to flexibility, dynamism, reuse of solutions, context dependency. Many roles oriented objectives can be naturally described with a hierarchical organization.

These three features are very important in open and dynamic environments, such as the Internet, where team members in online collaboration interact in order to collaborate. Some argue that many individuals and organizations are currently experiencing a growing need to search for alternative ways of working together. Herbst (1976) suggests that the traditional hierarchical model of organization, based upon the principles of vertical control and a single, uniform type of superior-subordinate relationship can no longer cope with the demands of our complex and rapidly changing society. McGregor (1957) argues that this model also ties workers to limiting jobs which do not utilize their capabilities, discourages the acceptance of responsibility, encourages passivity, and has eliminated meaning from work. People who are dissatisfied with working together under the hierarchical model are saying that managers above them in the hierarchy make their decisions without regard for the effect they had on the lives of people below them. However, we argue that the hierarchical organization provides a seamless environ-
ment for collecting, indexing and disseminating the information produced to the correct users at the right amount of detail. A good manager in a hierarchical organization encourages his subordinates to become positive, to accept responsibility and to like the work they do. He should have the capabilities to recognize and utilize his employees’ capabilities to the best. A good manager should effectively engage with his employees in setting, implementing and uptake of objectives, decisions and outputs. This can be achieved by running forums and meetings to display information, presenting and discussing alternative solutions so subordinates feel that they are partners in taking these decisions. Some people suggest that flat organization is a good alternative for the hierarchical organization. However, this argument is generally possible only for small businesses or enterprises but when they reach a critical size they cannot keep completely flat manager-to-staff organization and they must transfer to traditional hierarchical organization otherwise they may affect productivity. Certain financial responsibilities may also require a more conventional structure such as the hierarchical organization. In collaborative distributed computing which is a form of an online collaboration, some researches argue that there is no need for hierarchical organization in online collaboration where colleagues communicate with each other using emails and collecting information from different resources, this makes information items scattered on many different collaboration tools such as emails, file systems and web sites. However, each of these tools has its own hierarchical organization and there is a need to integrate them into a single hierarchical organization. In online collaboration, a large project needs to be divided hierarchically into smaller tasks that are sent out over the internet to be completed on personal computers. The technical challenge is to slice a project into thousands of tiny pieces that can be completed independently and then to reassemble them. Many people all over the world participate voluntarily in such large projects, as collaborative distributed computing only works if many people participate, the social problem is how to find all those widely spread collaborators and persuade them to participate (Holohan, 2005).

THE COMPOSITE ABSTRACT RELATIONSHIP

In this section we will discuss in details the composite abstract relationship between the hierarchical organization, information management and human collaboration. We start with the first part of this relationship which is between hierarchical organization and information management. In the next subsections, we will first discuss the issues, controversies and problems that face information management within an organization and then we discuss how hierarchical organization facilitates information management processes.

Issues, Controversies and Problems

All organization and enterprises, regardless of the internal and external environments in which they operate, need enormous amount of information. Management and operations within organizations and enterprises suffer from inefficient and ineffective information management processes, they do not benefit from their relevant and reliable information available from their information resources. In many organizations there is a great number of different information resources managed in different ways. They have no organized special libraries, information centers or services of any kind and also suffer from lack of well trained librarians and information professionals. Scholars have long been concerned with the impact of information management on the functioning of an organization. Some of this research
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has focused within the firm, and has considered whether greater computerization leads to increased or decreased centralization of decision making and standardization of work processes (Leavitt, & Whisler, 1958; Attwell, & Rule, 1984; Zuboff, 1988). Others have focused on the boundary of the firm, analyzing whether greater diffusion of information technology makes it more or less attractive to distribute organization’s activity across a network of markets rather than within a hierarchy.

Locating, retrieving, integrating, processing and disseminating information are activities of great importance for the successful functioning of organizations. The key issue facing information integration or fusion within an organization is locating and understanding both the information to be fused and the semantic relationships between information resources. Efficient structures are required for storing the meta-data across an enterprise, to make it easy to overcome the semantic heterogeneity between information resources and keep it over time. Lacking of efficient structures to store, retrieve and process information to fulfill the organization’s demand of information is a major problem. Some organizations implement the flat, linear or network structures to store and retrieve information. Some scholars argue that network organization provides a better environment for information exchange while other scholars argue that better information management can be performed using hierarchical structures. Network organizations are characterized by their fully distributed control that is no supervision is available, the keep of minimal amount of global information, cooperation among the network is loose and autonomous communication prevails. These characteristics of network organizations make them not favored for both information management and human collaboration. Better monitoring can be valuable within hierarchies which make them more attractive than networks for organizations. Hierarchical structures are favored for information filtering, retrieval and classification while in network organizations it is very hard to navigate the network searching for an information item. However, for the hierarchical organizations, difficulties remain in organizing and maintaining the hierarchical structure with growing size of the repository. Lopez (2002) argued that, the higher the position on the hierarchy, the larger the amount of information that can be handled. Lopez considered this a very interesting conclusion because it shows that the topology of this kind of organization benefits the nodes located in the upper levels of the hierarchy, allowing them to receive more information than all other nodes located under them. This means that the hierarchical structure guarantees that in terms of information, the efficiency of the relationships always improves when moving up in the tree. Thus, considering that all actors invest the same effort in relating with the others, the position on the hierarchy determines the amount of information that can be managed. The hierarchical organization provides the higher levels with high information centrality and improves their dominance of information. They can have the power to intercept, manipulate and obscure information. However, we do not consider the conclusions of Lopez as drawbacks for the hierarchical organization because they comply with the requirements of secure information exchange especially when relates to information of defense, intelligence, homeland security missions and financial responsibilities while basic information is made available to each actor in the hierarchy. In regard to the above problems, a key issue arises about the relationship between information management and the hierarchical organization, which is the question of “how does hierarchical organization facilitates information production, retrieval, fusion, display and diffusion”?

Solutions and Recommendations

In this section, we will discuss how the hierarchical organization addresses the problems and issues facing information management processes in work teams or organizations whether they are private or
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public. Information technology provides us with tools such as the multi agent technology and distributed computing technology to deal with these problems. A distributed multi agent system for collaborative information management and sharing was presented in (Chen, Wolfe, & Wragg, 2000) where collaborative agents help users access, manage, share and exchange information. The system has three types of collaborative agents:

1. Personal agents help their owners to find information to current needs.
2. Matchmaker agents designed to establish connections between users with similar interests and expertise.
3. System’s agents to provide needed services for users to share and learn information from one another on the World Wide Web.

This system provides tools and utilities for users to manage their information repositories with dynamic organization and virtual views. Collaboration between users is aided by easy exchange utilities as well as automated information exchange. Contents of repository are kept in object oriented storage to facilitate information exchange. Flexible hierarchical display is integrated with indexed query search to support effective information access. Automatic indexing methods are employed to support user queries and communication between agents.

In the next sub sections we will focus in more details on how hierarchical organization facilitates information management processes. According to the information life cycle model in Figure 2, the information management processes are:

1. Information gathering.
2. Information organization.
3. Information feedback.
4. Information retrieval.
5. Information exchange and security.
6. Information filtering
7. Information fusion.
8. Information display and visualization.

Information Gathering

Information can be created through the interaction between the organization and its internal and external environments. Internally, information can be produced while solving old and new problems through data collection, statistics and researches. Information comes through many different types of records, forms, monthly summaries, official reports and special studies which are prepared by staff at different levels and in different departments. Externally, the organization can interact with its external environment through sensors, emails, information gathering agents, interviews, surveys or web sites. While new information is continuously developed, organizations play an important role in identifying and organizing this information. Managers at different hierarchical levels must continually acquire and assimilate this information to affect the functioning of their organization.
A bottom up approach is considered very helpful for gathering, structuring and organizing information from one or more sources of expertise and its transfer to the knowledge base. Information is gathered at the lower level of the hierarchy using different gathering techniques which can vary based on the source and type of information as well as the intended use. Types of information and how they will be collected and reported, who will collect it, to what upper management level it will be submitted, how it will be used, and the level of details needed should be made clear to all members of the work team to ensure an appropriate flow of information in the correct sequence and the team knows how the information system functions. Questionnaire is a manual knowledge acquisition technique into which users write short answers to open questions or leave the questions blank. Observation technique is a time consuming technique, needs skill and is difficult to observe and analyze what was observed. Interview technique avoid many problems of questionnaire but it is hard to set up specially in structured interview where there must be a predefined structure and there is no flexibility in acquiring knowledge from an expert (Shouman, Abou-Ali, Mostafa, 2008). Records, reports, statistics and forms should be examined to see if they supply the required information to the upper management. In many cases, the upper management may need information that is not available from the reports submitted routinely. Special survey and research methods can be used to obtain this type of information. The team should be involved with an expert in the design and implementation of these special investigations as well as in the analysis and interpretation of the results. When improving, changing or creating some of the forms team members should be involved in these processes. Making sure that the design of the form facilitates recording and tabulating information accurately because time is wasted in filling bad designed forms as a large amount of information is lost and the form will be illegible. Some problems may occur during information collection, the team involved in the collection process should identify the source of these problems and how to eliminate them. In statistical signal processing, algorithms and studies utilizing sensor networks for detection and tracking are based on hierarchical organization that uses layers of clusters (Manjeshwar, & Agrawal, 2001; Zhao, Shin & Reich, 2002). Clustering is one of the commonly used methods to organize communications in large networks (Heinzelman, Chandrakasan, & Balakrishnan, 2000; Subramanian, & Katz, 2000). Hierarchical organization facilitates the transfer of information between clusters in different layers. Nodes send their information to the cluster heads via a single hop or multi hops depending on the size of the cluster. The cluster head can perform data aggregation and processing then relay the data to either a higher layer cluster head or the sink. Communications within each cluster are of the one-to-many type, that is data flows from each sensor to the cluster heads where they can be processed, compressed, aggregated and relayed (Enrique, Duarte, & Mingyan, 2003). During the collection of information from web sites over the internet routing of this information is an essential process. Hierarchical source routing has proven to perform well for information routing, compared to the global routing strategy which imposes no hierarchy such as distance vector and link state algorithms, while utilizing less storage and communication overheads (Awerbuch, Du, & Shavittb 2000). Hierarchical routing was suggested in (Castineyra, Chiappa, & Steenstrup 1996). In this approach, a network is grouped into hierarchy of nodes at various levels. Each node at a high level reports information for underneath topology to other interested nodes. Also, each node receives reported routing information from nodes in other domains and exchanges them information to other lower level nodes. As a result, each node needs only to maintain partial information about the entire network. Requirement on routing information storage at each node is substantially reduced. Sensory cortex is also arranged in a hierarchical organization, with information flowing from low level areas, which are closely tied to direct sensory input, to higher level areas, which are tied more to other corti-
neurons at lower level areas tend to have small receptive fields are tuned to localized features of sensory input, and thus tend to rapidly fluctuate in their activity in response to time varying sensory input. By contrast, neurons at higher levels have large receptive fields are tuned to more global abstract properties of the sensory world such as object identity, and are thus more invariant with respect to fluctuations in the raw sensory input (Redwood, 2007).

**Information Organization**

Information organization refers primarily to the logical arrangement of information topics in a file system. Nowadays, there is a wealth of information resources available for direct and easy access on the user’s desktop. However, finding appropriate information has become a significant problem for many users. Organized information spaces are easier to search. Once relevant information is found, pointers to it must be locally organized and stored in a manner that allows rapid and effective access for both individuals and workgroups. The most important factors for an effective information organization are:

1. The rapid access to an information topic or number of topics which are related to each other.
2. The adding, modification, or deletion of information topics.
3. Efficiency of storage and retrieval of information topics.
4. Ensuring integrity between information topics.

Current personal information organizing schemes on the World Wide Web are mostly limited to bookmarks which also called hot lists or favorites. Bookmarks provide an easy way to organize Unified Resource Locators (URLs) in a hierarchical manner and to attach personal comments to them. Although clearly superior to unstructured lists, hierarchical folder organization forces users to think in terms of a neatly decomposable structure consisting of disjoint clusters of related URLs (Chen, Wolfe, & Wragg, 2000).

The hierarchical relationship between information topics is used to organize them in a hierarchical organization where the parent and child topics are determined. In this organization, authorizing to access a parent topic automatically implies authorizing to access child topics. However, the converse is not true accessing a child topic does not imply accessing to any of the parent topics. To address the problems associated with using the hierarchical organization to organize information topics Shrideep, Geoffrey & Harshawardhan (to appear) noted in their framework that the creation request of a root topic should include information about:

1. Whether it allows hosting child topics, if so what is the maximum depth that is the maximum level including the level of that topic?
2. What is the maximum width that is the total number of immediate child nodes that any topic within the topic sub-tree can have?
3. Which would be the parent topic of the topic under consideration?
4. The topic creation request should also include information about entities that are authorized, or barred from either registering child topics or discovering the topic hierarchy.

To register an information child topic the immediate parent for that topic is determined and a check is made to verify that adding this topic to that parent will not violate any of the constraints specified by the
parent such as the maximum depth or maximum width. If a violation to these constraints is discovered then the adding process will fail. If there is no violation occurs then the hierarchical tree is updated to reflect the addition of that child topic. The life time of a child topic is determined by the life time of its parent. When a parent topic expires, all child topics also expire. The expiration time associated with a child topic never exceeds that of any of the parent nodes within its topic hierarchy. A topic collection is a tree based structure which is used to manage the information topics that comprise the collection. A collection may itself be composed of multiple collections. The constituent topics and collections may be added, removed or reorganized within the collection's structure. Additionally, a given topic or collection may be part of multiple collection concurrently. Figure 4 shows an example of collections tree where $T$ stands for an information topic and $C$ stands for a collection of topics.

**Information Feedback**

Feedback is a process by which effective performance is reinforced and less than desirable performance is corrected. Feedback should be information that highlights the relationship between what is expected and what has been accomplished after the work is performed or the action is taken. Feedback highlights the notion of temporal order, hierarchical organization and the necessary relation between its components. Mutual interaction occurs because the interacting processes are linked to each other the interaction is not an event but a process (Hector, to appear).

Hierarchical organization facilitates information feedback through a cyclic bottom up and top down operations where the top element in the hierarchy has control over lower elements. For example, our bodies are built in a hierarchical organization where the brain is its top element which controls the functions of all other body organs. By using the bottom up process the brain receives feedback information from the spinal chord which is in turn receives feedback information from body organs. The brain

*Figure 4. A collection tree*
analyses this information and by using top down process it sends command signals to the spinal chord which in turn sends it to body organs to perform a specific action (Hector, to appear). Figure 5 shows the relationship between the brain and body organs.

The relationship between production and consumption is another example of hierarchical organization. By using the bottom up process the producer receives feedback information about demands on its products. The producer then analyses the information and makes decision to whether increase or decrease advertisements and supply to the market. Figure 6 shows the production – consumption hierarchy.

The relationship between employees and supervisors also follows the hierarchical organization where supervisors are encouraged to gather data regarding employees’ performance at a systematic manner throughout the year. The performance feedback records are guides that can be used by supervisors, to assist their employees to enhance their skills and expertise to improve results. By using the top down process supervisors should communicate to employees to explain what is expected of them, define satisfactory criteria for those expectations. Then by using the bottom up process supervisors then evaluate the performance on an ongoing basis. Also, the relationship between departments and top management follows the hierarchical organization where the performance feedback statistics and reports are guides to the general director to evaluate the performance of each department. Expectations and guides should

Figure 5. Brain-body organs hierarchy (as adapted from Hector, to appear)

Figure 6. Production-consumption hierarchy (as adapted from Hector, to appear)
be provided to each department. Figure 7 shows the supervisor-employees and department–top management hierarchy. In this hierarchical organization there is a hierarchy of levels (Top Management (General Director) / Middle Management (Supervisor) / Low Management (Employees)) that interact with each other in continual processes of mutual and hierarchical feedback. Together, bottom-to-top and top-to-bottom actions constitute a cycle, a continuously operating feedback.

Artificial neural networks are another example of how the hierarchical organization facilitates information feedback to improve performance. Artificial neural networks consist of neurons which are organized hierarchically into successive layers; each neuron in a layer is fully connected with all other neurons in the upper layer. The hierarchical organization facilitates the flow of feed forward information and the back propagation of feedback information between layers to enhance network learning which in return increases its recognition rate. The running of the network consists of two passes: the forward pass and the backward pass. In the feed forward pass information flows from the input layer to the output layer to adjust the weights between neurons. Then outputs are calculated and the feedback information which is also called error is calculated at the output units. In the backward pass feedback information, which is the calculated error, is back propagated from the output layer to the input layer to correct the weights of the network connections between neurons of these layers. This process is performed iteratively to minimize the back propagated error and to increase the network performance. Figure 8 shows an artificial neural network model.

Information Fusion

Applications might require information fusion from a handful of information sources to literally hundreds of sources. The information could be (Simoff, & Maher, 1998):

1. Structured data files such as stored in database management systems or specific applications such as data warehousing, enterprise resource planning, scheduling, payroll, finance and accounting.
2. Semi-structured data files such as HyperText Markup Language (HTML), eXtensible Markup Language (XML), or Standardized General Markup Language (SGML) files.
3. Unstructured text data files, such as contracts, specifications, catalogs, change orders, requests for information, field reports, and meetings.
4. Unstructured graph files stored in binary format such as 2D and 3D drawings.
5. Unstructured multimedia files such as pictures, audio, and video files.

The main goal of using the hierarchical organization in information fusion is to increase the fidelity and availability of information within the organization. Since a single source of data can generally perceive limited partial information about the problem, multiple similar or dissimilar data sources can provide sufficient local pictures with different focus and from different view points in an integrated manner (Zhou L., 2007). Information fusion is about integrating information from different sources in order to facilitate understanding or provide knowledge that is not evident from individual sources. Information from heterogeneous data sources can be combined using data fusion algorithms to obtain clearer picture about the problem (Xiong, & Svensson, 2002). In hierarchical organization, data gathering occurs at the lowest level where simple information fusion and raw data of the functional units are produced. The resulting information is interpreted and then fused to extract higher level information. This could be achieved through a distributed database where each functional unit within a working group maintains a local database to access the information it needs to perform its function and then processes and transmits its best available information for use by another functional unit within the same working group. The information resulted from fusion or integration is reported to the parent node where it is available for any other child or working group to get use of it. Qiuming, Stuart, & Tomas (2007) proposed a hierarchical collective agent network for information fusion and management which utilizes a sophisticated multi-agent collaborative structure combined with a feedback mechanism to gauge performance and drive system configuration. This model can also consider management at both the sensor level and the
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higher system level of the total platform capability and its mission. The hierarchical collective agent network possesses the properties that agents are grouped in layers which organized hierarchically. Agents within each layer are weakly connected while agents between layers are strongly connected. The control and coordination of the agents at each layer are carried out through the agents at the higher layer. Weakly connected means that interactions between the agents are mainly data communications only, no control function takes place, while strongly connected means that agents on the two ends of the link have both data exchange and control relations. Figure 9 shows the hierarchical collective agent network of agent collaboration. In the hierarchical organization the collective nature of agent relation simplifies the functional design of the agent interactions and enhances the security and efficiency of the information processing, an advantage over the web-like and grid-like topologies. Also, it relieves the burden of intensive data exchange between fellow agents in star like topology by limiting agent communication to vertical layers of the assembly only.

The hierarchical collective agent organization thus strikes a balance between the centralized control and distributed computation by allowing distributive agent operation within layers of the hierarchy and enforcing centralized control between the layers of the hierarchy, thus creating a federated agents integration structure. The hierarchical structure of the model facilitates the on-site analyses of the collected data and extraction of information that is useful for the control agent to coordinate the actions of the distributed agents or agent groups (Qiuming, Stuart, & Tomas, 2007). In problem decomposition, the hierarchical organization simplifies a large problem by dividing it into well defined sub-problems, which are again divided into sub-problems recursively until a trivial solution can be calculated at a lower level. Afterwards the solutions of the sub-problems are passed to the higher level to fuse or integrate together and reach a solution to the main problem. This strategy can be applied as is to achieve recursive problem decomposition. As the smaller tasks are usually independent of one another, the tasks can be calculated in parallel, this reduces significantly the time complexity required to solve the main problem. Parallel sorting algorithms often use hierarchical recursive decomposition. The hierarchical organization also facilitates the integration between different models which helps in information fusion. A hierarchical hybrid Bayesian network consists of a Bayesian networks model at the top layer serving as a fusion center, several Hidden Markov Models at the bottom layer belonging to several agencies serving as information filters, they process the raw information and provide soft evidence to the corresponding Bayesian network.

Figure 9. Hierarchical collective agent network of agent collaboration (as adapted from Qiuming, Stuart, & Tomas, 2007)
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node where the Bayesian network is maintained by another agency. Raw information is represented by transactions and information entities to be integrated are modeled as random variables. Each random variable has certain states with probabilities assigned to them (Haiying, Jeffrey, Satnam, Krishna, & Peter, 2006). Figure 10 shows the hierarchical hybrid Bayesian network for information fusion.

Also, the hierarchical organization facilitates the use of ontology for information fusion. Fig.11 shows a hierarchical model for gathering provenance information from different sources for decision making (Fred, 2006). Ontology is used at the top layer for information fusion. At the lower layer information is gathered from different sources such as images, maps and texts which are then transferred to the middle layer the Resource Description Framework (RDF). RDF is an infrastructure that enables encoding, exchange, and reuse of structured metadata. It uses XML (eXtensible Markup Language) as a common syntax for the exchange and processing of metadata.

The main requirements for all information fusion or integration models are that the information to be fused or integrated must have a well defined measure of uncertainty and confidentiality and that the information fusion process must ensure that the databases maintained by all functional units after fusion remain consistent. Information consistency is necessary to get rid of redundant information which has a disastrous effect on information fusion. Information consistency can be maintained using the hierarchical organization while it is not possible in network organization, web-like or grid organizations.

Information Retrieval

An efficient retrieval process can be achieved using a top down approach of successive refinements to narrow the domain of search in geometrically successive fashion. This is accomplished by decomposing the retrieval process hierarchically into successive steps each of which involves decisions about only a few major alternatives, in such a way that decisions at earlier steps facilitate more detailed decisions at later steps (Eylon, & Reif, 1979). This suggests the hierarchical organization for information retrieval tasks, where knowledge is subdivided into knowledge units related in such a way that a few information items in any unit are elaborated by further description through subordinate knowledge units. Figure 12 shows a classification tree to classify a person into either a purchaser or non-purchaser class.

As more information becomes available the search space narrows as we go down the hierarchy. This elaborates that the hierarchical organization of knowledge facilitates information retrieval using a top down approach.

For an efficient and rapid retrieval of images hierarchical organization facilitates the matching of image segments from different scenes. The primary advantage of using the hierarchical organization in scene representation is that image information is represented in a structured manner. The top node of the structure contains information about the entire structure, such as its total size, average intensity or amplitude, and other features which describe globally the entire set of segments which makes up the structure. Lower level branch nodes similarly contain information about all nodes subordinate to them. Thus, by examining only the top layers of a structure, it is possible to extract a great deal of information about the structure and its components. The hierarchical organization explicitly encodes valuable high level information. This high level information includes the relationships between the segmented regions in an image which include perceptual features such as proximity between segments, similarity of intensity or amplitude, and other features which may be valuable in both characterizing the nature of a structured cluster of segments, and in facilitating matching between sets of segments from one image to sets of segments from another image. The unique encoding of hierarchical data structures
facilitates rapid identification of significant and/or strongly differentiated areas of interest in each image (Allanna, Robert, & Craig, 1989). Information retrieval search engines can get more accurately and organized results if the search terms are organized in hierarchical structure which is called the query tree. By providing an order in which web pages are searched or retrieved by following a specific path the search engine can quickly narrow down the search space and obtain the desired data. An example of such search engine is the World Wide Web based Information Retrieval and Extraction system WIRE mentioned in (Aggarwal, Hung, Weiyi, 1998). WIRE permits users to provide examples and patterns that help in the search and information extraction. The examples and patterns are associated with the search terms of the query tree. They are hierarchically organized into a paradigm tree that is similar in structure to the query tree.

With growing size of the World Wide Web and becoming a prevalent source of information in scientific researches and everyday life, bookmarks strategies are widely used to relocate sites of interest that allow the user to create a personalized Uniform Resource Locator (URL) repository, which facilitates
easy and fast access to relevant information (Abrams, Baecker, & Chignell, 1998). Traditionally, these repositories are stored on the client side and can be organized in a hierarchical folder structure via the browser interface. Recently, server side mechanisms like the so called “Social Bookmarking” have gained popularity (Hammond, Hannay, Lund, & Scott, 2005). Hierarchies are the primary organizing principle for many document classification systems. Cataloging systems (OCLC, 1993) uses a classification hierarchy to facilitate browsing and searching it has been implemented and currently runs with over 50,000 book records. The system’s interface allows the hierarchy to be displayed and traversed easily. A search query is applied to documents in a document repository where documents are organized into a hierarchy. A search engine searches the hierarchy to return documents which match a query term either directly or indirectly. It organizes the query term into individual sub-terms and matches the sub-terms against documents returning only those documents which indirectly match the entire search query term and directly match at least one of the query sub-terms. The Dewey classification system which is probably the most widely used international classification system is the purest hierarchy of the major library classification systems (Robert B., 1994). A study was designed to investigate forms of human internal knowledge organization that facilitate the recall of information or its use for complex problem solving tasks. A hierarchical organization model was specified and designed to facilitate selective information retrieval constructed by successive elaborations of a few top level ideas most important for a specific task domain. Subjects with such a hierarchical organization performed appreciably better compared to subjects with a single level organization of the same knowledge (Eylon, & Reif, 1979).

Gaining access to the right information to make critical decisions can often be more difficult than it first appears. Organizations can own a huge amount of information, but one often find it difficult to get this to the right people in the right time to effect changes that will benefit the organization. A common problem facing organizations is information overload, as the levels of explicit knowledge become

*Figure 12. Classification tree (as adapted from XLMiner, 2007)*
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so overwhelming that they cannot be appropriately filtered. Information overload refers to the state of having too much information to make a decision or remain informed about a topic. It is often referred to in conjunction with various forms of computer mediated communication such as emails and web sites. Research shows that many members of organizations may receive regular reports but often they are not tailored to their needs, pertinent to them or in helpful formats. As more and more people in the organization need to make decisions based on accurate and up-to-date information, they need to receive important information but do not want to be flooded with unimportant information. The general causes of information overload include:

1. An increasing rate of information production.
2. Too much useless information.
3. Information can be easily duplicated and deployed over the internet.
4. Information can be received through multiple channels such as telephone, emails and instant messaging.
5. Large amount of stored information to mine through.
6. Contradictions and inaccuracies in available information.
7. A lack of methods for information filtering.

Email remains a major source of information overload, although people should be delighted with the growing use of e-mail attachments in the form of lengthy reports, presentations and media files, they struggle to keep up with the rate of incoming messages. In a world increasingly filled with a flood of information and with users strained for available time, filters will assume an important role in the acquisition of information (Rajeev R., Snehasis M., Michael B., & Nila P., 1997). Filtering out unsolicited commercial messages, help users to keep up with their important messages. Information filters are programs that select and prioritize information according to the instructions, needs, or customs of a given user. Keeping efficient indexes of historic information also facilitates information filtering where indexes are usually based on hierarchical organizations. These indexes prevent users from creating new files and generating new reports which might exist and therefore reduce the problem of information overloading and inefficiencies in the storage of information. A hierarchical multi-agent system based on the model of beliefs, desires and intentions for retrieving information from heterogeneous databases is used for fast retrievals of heterogeneous distributed information over different data sources. A model for information filtering to solve the information overload problem on the web was presented by (Li, Zhang & Swan, 2000). The model hierarchically describes the user information need into two levels: profiles on category level and Boolean queries on document level. To efficiently estimate the relevance between the user information need and documents, the user information need is treated as a rough set on the space of documents. The rough set decision theory is used to classify the new documents according to the user information need. In return for this, the new documents are derived into three parts: positive region, boundary region, and negative region. This approach was shown to be effective in solving the information overload problem. The web search engine WWW based Information Retrieval and Extraction system (WIRE) mentioned in (Aggarwal, Hung, Weiyi, 1998) has a sophisticated filter mechanism, the filter conditions which could be local, global or structural are organized in a hierarchy called the restriction tree. Also the queries of WIRE are tree structured. WIRE provides an order in which web pages are to be searched and filters out undesired information to further improve retrieval accuracy.
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Information Exchange and Security

Information exchange, distribution or diffusion is the timely collection, exchange and distribution of information to the work team. This information needs to be delivered in the right format and at the right time to the right place to ensure that informed team decisions can be made. Information diffusion can take place through formal or informal mechanisms. Information technology’s exchanges capabilities make it easier and less costly communicate the required large volumes of information across organization boundaries (Malone, Yates, & Benjamin, 1987; Clemons, Reddi, & Row, 1993). Management decisions can largely influence the flow of information within the organization. As the hierarchical organization reflects the position each actor occupies in the organization, it reflects authority relationship among actors, showing that there exist a close connection between the hierarchical level of an actor and the information it receives, benefiting the hierarchical levels in terms of information transfer. Therefore, managers should manage the process of information diffusion within an overall strategy to achieve the organization’s goals.

In information exchange multi agent based model each data exchange node serves as a basic organization which can send and receive information automatically and store the information. The model has a hierarchical organization of multi-agents which cooperate to realize the exchange and the integration of information. Multi agent coordinating information exchange model adopts the tier-based configuration which is composed of three basic organizations namely the Information Processing Center Basic Organization which serves as the root node. This root node has two subordinates Information Processing Sub-Node 1 Basic Organization and Information Processing Sub-Node 2 Basic Organization. Each of these subordinates has also a hierarchical organization of multi agents which contains agents to send, receive, evaluate and manage information. Figure 13 shows the architecture of the coordinating information exchange model. Figure 14 shows Information Processing Sub-Node Basic Organization. Figure 15 shows Information Processing Center Basic Organization (Xing-kai, & Yan-zhang, 2006).

Huang, Shian-Shyong, & Wu, Haung, Shian-Shyong, & Zhang (1999) proposed a knowledge sharing and collaboration system hierarchical model based on internet called the “Internet Knowledge Based” system. It facilitates collaboration and sharing knowledge between web-based knowledge systems. This model is composed of three hierarchical layers namely, the Data Exchange layer, Collaboration layer and Knowledge-based Application layer. Data Exchange layer solves the problem of how to represent and manipulate knowledge.

Collaboration layer devotes to collaboration between servers over internet. Knowledge-based Application layer defines the user interface for knowledge processing over internet such as information searching, decision support application and data mining. Data exchange between the Internet Knowledge Based Webs is in XML format, knowledge can be shared between heterogeneous knowledge bases, and knowledge can be remotely manipulated. Collaboration between Internet Knowledge Based systems is supported through collaboration agents to resources a user wants. Also, the Internet Knowledge Based system can support information retrieval and browse. Information security is a critical point in the field of information exchange where hierarchies are an important concept in information protection systems. Integrity, confidentiality, authenticity and traceability have to be guaranteed for transferred information (Kunis, Rünger, &Schwind, 2007). The uses of hierarchies in the security domain of computer information systems include access hierarchies, levels of abstraction in security kernels, multi-level security and user hierarchies among others. Security levels are organized into a hierarchical order in the multi-level security that prevents downward information flow from a high security level to a low
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security level (Gollmann, 1999). Basic information which is easy to obtain is located at the bottom and the higher order need located at the top. At the very bottom of the hierarchy is open information which is not secure at all, it is how most enterprises, financial institutions and government agencies share information. The next level is basic point-to-point encryption for a specific data stream, which must be set up and torn down on a case-by-case basis. The third layer is network encryption, which provides secure information exchange on a broad level (CipherOptics, 2008). Figure 16 shows the security levels of information exchange hierarchy. A user hierarchy is defined as a network structure of users arranged in the order of their authority in the organization. Figure 17 shows a user hierarchy. An arc between two users indicates that one is the supervisor of the other. An information protection system should be able to store, verify, and guard such a user with rigorous discipline. In Figure 17 for instance, the protection system should grant the request of user c to read a file of user e since user c is superior to user e. On the other hand, the system should deny a similar request for user b to read file of user c because user b is a sibling of user c and does not possess such access rights.

Figure 13. Architecture of the coordinating information exchange model (as adapted from Xing-kai, & Yan-zhang, 2006)

Figure 14. Information processing sub-node basic organization (as adapted from Xing-kai, & Yan-zhang, 2006)
In effect, the confirmation of the arcs and hence the relationships between users in the hierarchy will help determine the appropriateness of any further tasks performed by the protection system.

**Information Display and Visualization**

A large quantity of the world's information is hierarchically structured: manuals, outlines, corporate organizations, family trees, directory structures, internet addressing, library cataloging, and computer
programs...etc. Most people come to understand the content and organization of these structures easily if they are small, but have great difficulty if the structures are large (Brian, & Shneiderman, 1991). To display hierarchical information traditional methods are classified into: listings, outlines and tree diagrams. It is difficult for people to extract information from large hierarchical information structures using these methods as the navigation of the structures is a great burden and content information is often hidden within individual nodes (Kim, Brian, & Robert, 1987). The tree map visualization technique was proposed by (Brian, & Shneiderman, 1991). Tree mapping is a method for displaying tree-structured data using nested rectangles. Hierarchical information structures contain two kinds of information: structural information associated with the hierarchy and content information associated with each node. Tree maps are able to depict both the structure and content of the hierarchy. This approach is best suited to hierarchies in which the content of the leaf nodes and the structure of the hierarchy are of primary importance, and the content information associated with internal nodes is largely derived from their children.

The Tree map visualization method maps hierarchical information to a rectangular 2-D display in a space-filling manner, where 100% of the designated display space is utilized. Interactive control allows users to specify the presentation of both structural as depth bounds...etc. and content display properties such as color mappings information. With the Tree-map method, sections of the hierarchy containing more important information can be allocated more display space while portions of the hierarchy which are less important to the specific task at hand can be allocated less space (George, 1986; Tyson, & Scott, 1990). This tree map approach was successfully applied to computer directories, sales data, business decision making (Asahi, Turo, & Shneiderman, 1995) and web browsing but user take 10-20 minutes to accommodate to complex tree maps (Mitchell, Day, & Hirschman, 1995; Mukherjea, Foley, & Hudson, 1995). Figure 18 shows tree map visualization for a representation tree.

In case of multi-dimensional data, stacked display techniques are tailored to present data partitioned in a hierarchical organization. Data dimensions to be used for partitioning the data are building the hierarchy have to be selected appropriately. The basic idea is to embed one coordinate system inside another coordinate system, i.e. two attributes from the coordinate system and two other attributes are
Figure 18. Tree map visualization for a representation tree (as adapted from Re’mi, 2002)

(a) A node-link representation tree

(b) The corresponding treemap

embedded into the outer coordinate system and so on. The display is generated by dividing the outmost level coordinate system into rectangular cells and within the cells the next two attributes are used to span the second level coordinate system. This process may be repeated more than one time. The usefulness of the resulting visualization largely depends on the data distribution of the outer coordinates and therefore the dimensions which are used for defining the outer coordinate system have to be selected carefully (Keim, 2002). Figures 19 and 20 display the population of the United states circa 2000 as a
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Figure 19. Stacked bar showing United States population for states and regions (Corbet 2003. Used with permission)

stacked bar chart. Height represents population, boxes represent regions and states. By clicking on the West, would scale the data so that the West filled the available height. In this view, it is apparent that California is more populous than the entire Mountain region.

In case of visualizing the World Wide Web information, one difficulty is representing the quantity of information and its distribution within a set of linked documents. This information along with the type of document such as text, image, audio,…etc. can be helpful on deciding whether a web site may be interesting or useful without spending a great deal of time browsing the deep structure of the site. Nation, Plaisant, Marchionini, Komlodi (1997) developed a tool called WebToc to visualize web sites using a hierarchical table of contents browser it consists of two parts: the parser and the viewer. The parser starts with a web page and follows all the local links generating a hierarchical representation of the documents local to the site. The viewer displays this information as a table of contents for the site using a standard web browser by following the links included in the documents and treating each new set of links as another level of the hierarchy. The lines of text in the web browser each represent a link to a document which may be another web page or a multi-media file such as an image or audio file. In addition, to the lines of text, each local document is represented by a colored line with a length corresponding to the size of the file. The color of the line represents the type of file such as text, image or audio. When a document contains links to other documents, the lines representing the documents it includes can be collapsed into a thicker size bar that shows the total size of the document it references. Each size bar has a shadow under it. The size of the shadow indicates the number of items subordinate to the document it represents. This gives a visual cue to let the user distinguish quickly between items with a few subordinate links or many links. Figure 21 shows a representation of the HCIL Web site using a hierarchical organization which clearly indicates that the largest number of documents is included
in the Students: Graduate and Undergraduate branch. The message in the status area at the bottom of the browser indicates the actual number of items and size for that branch.

Information Disposition

It is the practice of handling information that is less frequently accessed or has met its assigned retention periods. The information disposition process enables an organization to dispose information which no longer has operational value, either by permitting their destruction or by requiring their transfer to library and archives or by agreeing to their alienation from the control of the organization. Information organization process is used to store this information into libraries or archives.

HUMAN COLLABORATION AND INFORMATION MANAGEMENT

In the previous section we discussed the issues, controversies, and problems facing information management processes within organizations and work teams, and how the hierarchical organization facilitates information management processes to solve these problems better than any other alternative organizations. In this section, we discuss the issues, controversies and problems facing human collaboration and we will show how information management improves the role of collaborators within their work teams.
Issues, Controversies and Problems

Two groups of problems are identified: problems of coordination, misinformation and misunderstandings and problems of cultural differences and information security. Greater coordination problems are associated with size, distance, interdependence and scientific competition. Problems of culture and security are associated with size, distance, scientific competition, and commercialization. Email use is associated with reporting fewer coordination problems, but not fewer problems of culture and security, while neither phone use nor face-to-face meetings significantly reduces problems. Group cohesion has an impact on collaboration problems. It is measured in terms of tie strength and consistency with social network theory. A collaboration rich in strong ties will report fewer problems with coordination and misunderstandings. Similarly, groups with many strong ties that are with high cohesion should have fewer problems of trust, security, and cultural differences (Walsh, & Maloney, 2007). Information flow
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requires links between team members; some argue that loosely linked networks allowing new information to flow (Burt, 1992; Podolny, & Baron, 1997). Others argue that strongly linked networks facilitate information flow especially if they are complex in nature. Higher degrees of group cohesion increase group adherence to group norms and facilitates communication and information flow. Work teams have to decide on a division of labor, overcome planning and scheduling issues, monitor and coordinate progress, possibly deal with distinct cultures, languages and worldviews, and ensure that information flows where it should and does not leak to where it should not. When not carefully controlled, these processes create strain in collaboration and can impede progress (Fox, & Faver, 1984).

Recent advances in communication and information technology have changed the face of human collaboration. They improved the ability to share information between team members at different organizational levels which has a direct impact on building a shared awareness and decision making. Despite these improvements, however, information technology is not without its problems. Because of the tremendous amount of data available, collaboration teams are often faced with information overload. Much of that information comes from open sources such as the internet. As a result, knowledge uncertainty becomes a primary concern (Warner, Letsky, & Cowen, 2005; Warner, Letsky, & Cowen, 2004). On the World Wide Web a novice user finds a difficulty to differentiate between useful and useless information. A major problem is documenting every change has done and tracking every revision needs some consistency or they risk violating rules or loosing the critical trail of work that was part of a work plan. Other problems that can face team collaboration are time pressure and dynamic information. Therefore, our key issue in this section is the question “how human collaboration can be improved using information management”? Information management within the hierarchical organization can help human collaboration by honoring and supporting both integrity and autonomy of each individual. It helps people to communicate well. Information management causes people to have trust, mutual respect, co-creation, empowerment and sufficient communication within a superior-subordinate relationship. Also, decisions can be made in a sense that can respect the different views of people in an organization. Surveys help in using the consensus style of decision making where the collected information are analyzed and moved to upper management to guide them for the decision. By using information management we believe that collaboration is using in a principled way some objective criteria or objective standards to decide what method to use to make decision. There are times when it is appropriate to gather information from the whole group when it’s affected, there are times when it’s appropriate to delegate and then taking some feedback information when people are going to call you on it.

Solutions and Recommendations

Due to the big advances in information technology as we experience nowadays we can show that the hierarchical organization with its effect on information management processes can significantly improve human collaboration.

In this section, we will discuss the impact of information management processes on human collaboration models. Firstly, we will discus the primary processes that might occur in each collaboration process and then we will discus the effect of information management on the performance of human collaboration models. As suggested by Bolstad, & Endsley, (2005) the primary processes for team collaboration include:
1. **Planning and scheduling:** Planning in hierarchical organization proceeds by decomposing tasks recursively into smaller and smaller subtasks, until primitive tasks which can be performed directly using the planning operators, are reached. For each task, the planner chooses an applicable method, instantiates it to decompose the task into subtasks, and then chooses and instantiates other methods to decompose the subtask even further. If the constraints on the subtasks or the interactions among them prevent the plan from being feasible, the planning system will backtrack and try other methods. The Hierarchical Task Network (HTN) planning method is conceived of as a useful method for web service composition as well as task planning, and several works on the web service composition have been attempted with HTN (Nau., Au, Ilghami, Kuter, Murdoek, Wu, & Yaman, 2003). Many task-oriented objectives can be naturally described with a hierarchical structure. The purpose of a hierarchical task network planner is to produce a sequence of actions that perform some activity or task. Different decompositions of a task are independent so the designer of a method does not have to know how further decompositions it will go. The description of a planning domain includes a set of planning operators and methods, each of which is a prescription of how to decompose a task into its subtasks or smaller tasks. The description of a planning problem contains an initial state as in classical planning and instead of a goal formula there is a partially ordered set of tasks to accomplish. Methods by decomposing tasks recursively into smaller and smaller subtasks, until primitive tasks which can be performed directly using the planning operators are reached. For each task, the planner chooses an applicable method, instantiates it to decompose the task into subtasks, and then chooses instantiates other methods to decompose the subtasks even further. If the constraints on the subtasks or the interactions among them prevent the plan from being feasible, the planning system will backtrack and try other methods. Staff scheduling, also known as workforce allocation, creates schedules that provide the best possible coverage and meet employee preferences (Tiehua Z.; Gruver, W.; Smith, M., 1999). Scheduling assigns a task for each team member for each day and gives information about when a task might be implemented. Scheduling algorithms based on artificial intelligence techniques and algorithms generate an ordered list of activities. A model of the tasks to be scheduled is first generated which describes the possible set of activities, the constraints between those activities, and the resources required for each activity. Several algorithms such as “Automated Scheduling and Planning Environment” (ASPEN) have been implemented for generating initial schedules from the requests, and repairing existing schedules with conflicts. These algorithms are generic and can be used on any given model. The scheduler determines the conflicts in an input schedule of requests and loops through all of the conflicts, trying to resolve each by performing a schedule modification. A conflict in the schedule is simply a violation of one of the resource, state, or temporal constraints defined in the model. The modifications it can perform include moving, adding, and deleting activities (Paul, Kam, & Gregory, 1998).

2. **Tracking information:** Is a type of information that includes identifying information which is distinguishable from the produced information. It is used to track the information as it flows between team members at each stage of the collaboration process or between individuals at different levels of the hierarchical organization. Tracking information can be used to make a complete trace of the processes that contributed to a topic of information’s pedigree. Recording such a trace of all the processes upon which information depends may be useful for a variety of reasons, e.g., explaining how results were obtained, vetting results from unknown, untrusted, or unreliable processes, and selecting follow-on tasks to perform (Christopher, William, Paulo, Deborah, David, & Richard, 2005).
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3. **Brainstorming**: Helps a team to create a list of tasks when planning for a project, analyzing potential problems and finding creative solutions. It allows for group discussions between team members rather than the opinion of a single person to discuss problems, finding possible solutions, choosing the most feasible solution, identifying the most appropriate methods to achieve the goals of a project, and finding the most efficient means and strategies for problem solving and tasks implementation. The results can be uploaded to the team’s web site allowing non-member individuals to review and propose amendments. This will help to explore hidden potentials of the project and find numerous possible solutions to the assigned tasks.

4. **Document processing**: A document is a bounded physical representation of information designed with the capacity and intent to communicate. A document may record symbolic, diagrammatic or sensory representational information. To create a document is to edit by collecting and representing information. Conventionally, a document is understood as ink marks on a paper, containing information. Increasingly, documents are also understood as digital documents such as e-mails and reports generated by word processors (Michael, 1997), they are digital artifacts caused by digital encoding of information. The document started as a pending or draft document created by a team member. The supervisor would then approve or reject the document. Once approved, the document is made available in the working development library for other users with security rights. If rejected, the document stayed as pending and was not published for the group to see. Raphael, Gudula, & Michael (2007) introduced a flexible, adaptable document management system for e-governments to face the challenges of increasing efficiency and quality while decreasing the processing time. This system is based on hierarchical process folders and information security levels. A hierarchical process folder mainly consists of files that belong to a government process and includes all documents processed during process execution. The folder grows during execution and contains all versions of changed, existing, and added documents. This means that the model of hierarchical process folders can be deployed to exchange process folders in whole or in part between authorities to support the execution of distributed hierarchical government processes. With large document processing systems in e-governments the hierarchical design is necessary because parts of the processes are executed on external systems. Instead of copying the overall process to all involved systems only the needed small parts that should be executed have to be available.

5. **Information gathering and retrieval processing**: Possible mechanisms for collecting and sharing of information are manual filing, electronic databases, collaboration software, and management information systems (Anticlue, 2006). Effective information gathering is the most important process an effective team requires. Good quality information marks out the context in which the team operates, creates the information patterns from which ideas emerge, and provides the criteria by which ideas are screened and assessed (MindTools, 2008). Information types that are involved in human collaboration include:
   1. Verbal (Speech) information.
   2. Textual information.
   3. Spatial/graphical information - such as maps or drawings
   4. Emotional information - including fatigue, workload, competence, and anxiety which are often important in team collaboration activities
   5. Photographic information.
   6. Video information.

Effective team members gather two main types of information (MindTools, 2008):
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a. **Background information:** This information is made up of the countless facts, trends and opinions that team members encounter and the observations they make on a daily basis. The higher the quality of background information gathered the more accurate their view of the world will be, and the better their judgment and common sense. Background information on the environment the team working in can be gathered using:
   1. Reading newspapers and magazines.
   2. Reading websites.
   3. Talking to people.

b. **Task-related information:** The amount of information required depends on the scale of the decision, the time available, and the consequences of getting it wrong. Talking to experts, knowledgeable people and reading related magazines and brochures in the field are important tools for gathering related information.

6. **Information distribution:** Team collaboration must be characterized by open, timely, and reliable information exchange. The main objective of information distribution is to make sure that the right information is available to the right people at the right time. Information distribution executes the communication plan and responds to the unexpected requests for information. The distribution mechanism can affect the information's usefulness because if it is not timely or comprehended, then it shouldn't have been communicated. Methods of information distribution can be portals, collaborative work management tools, web conferencing, web publishing, and if all this technology is not available, manual filing systems and hard copy distribution are used (Anticline, 2006). Team members achieving fully integrated collaborative team through information distribution early in the project process are most likely to achieve the desired outcomes: fast, efficient, effective, and cost-bound buildings (CURT, 2004). Such collaboration transfers the bulk of analysis, design, and decision-making earlier in the design process, thus giving the collaborators a good chance for making good decisions. One of the products of information distribution is the information feedback that catches the project status, issues and progress reports. This information can be used to modify or improve future project performance.

7. **Shared awareness:** Awareness usually refers to the information about the activities of other team members (Dourish, & Belloti, 1992; Gutwin, & Greenberg, 2000; Matsuura, Fujino, Okada, & Matsushita, 1996). Awareness is useful in linking different components of the collaborative system including team members. There are many types of awareness information include:
   a. Activity awareness, which is information about the related activities of other team members. During real-time collaboration, this may simply mean knowing what actions others are taking at any given moment.
   b. Availability awareness, which is information about the physical availability of people and their willingness to social interaction or informal encounters (Tollmar, Sandor, & Schemer, 1996).
   c. Process awareness, which is often found in workflow management systems, where the tasks are usually well defined and represented by a series of sub-tasks. Workflow systems generally assert more control in information flow and the order in which tasks are completed (Prinz, Rodden, Syri, Trevor, & Modeling, 1996).
   d. Perspective awareness, which is not only information about background, beliefs and knowledge, but also information on how particular actions emerged. (Boland, Schwartz, & Tenkasi, 1992; Gutwin, & Greenberg, 2000).
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e. Environmental awareness, which focuses on events occurring outside of the immediate workspace that may have implications over group activities (Fussell, Kraut, Lerch, Scherlis, McNally, & Cadiz, 1998).

To develop shared awareness between team members Bolstad, & Endsley (2005) provided a taxonomy of collaboration tools for information sharing such as face-to-face, video conferencing, audio conferencing, telephone, networked radio, chat/instant messaging, white board, file transfer, program sharing, email, groupware, bulletin board, management information systems and domain specific tools as shared awareness requires integrating information from multiple sources.

HUMAN COLLABORATION MODELS

Several models of team collaboration have been proposed (Orasanu, & Salas, 1992; McNeese, Rentsch, & Perusich, 2000; Cooke, 2005). In this section we will discuss some of these models:

   1. **The first stage:** Individuals work independently, interacting only at a basic level by sharing information to meet their own specific needs.
   2. **The second stage:** Individuals engaged in information exchange because of common interests, but not with the intent of achieving a common goal.
   3. **The third stage:** Individuals work as a team to achieve a common goal by sharing information and, as a result, gain new insights. This is the highest level of collaboration and the focus of most collaboration technology.

b. A research group identified three distinct stages of collaboration (Ancona, & David, 1990):
   1. **The creation stage:** Team members meet together to learn about each other and come to agreement about how to proceed. Tasks centered on exploring the problem, possible solutions, and available knowledge and resources. Team members’ attention was focused outward, on research activities and networking, and inward, on team building and role clarification (HermanMiller, 2002). Information sharing facilitates team learning while information gathering, retrieval, fusion and exchange facilitate exploring the possible solutions.
   2. **The intense development stage:** Team members involved in intense interaction, although the team was still drawing on external resources as needed.
   3. **The diffusion stage:** The team worked to transfer ownership and commitment to others in the organization. The diffusion phase requires members to stay in contact and commitment while being in touch with other outside the team. Focus turned outward, as team bonds began to loosen and individual members were drawn off into other projects (HermanMiller, 2002)

c. Gutwin & Greenberg (2000) have developed a conceptual framework, the mechanics of collaboration. Their framework suggests that there are two major types of work involved in collaboration: teamwork or the work of working together and task work or the work that carries the task. These types of works imply two main types of activities namely: communication and coordination from which four categories of mechanics are derived:
   1. **Explicit communication:** It is considered to be fundamental to collaboration, it is essential for identifying the information needs. The purpose of communication is to exchange in-
formation at its best to assure all intended receivers can use the distribution methodology (Anticue, 2006). Four types of communication are involved: spoken, written, gesture and electronic. Electronic communication tools send messages; files, information or documents between people hence facilitate the exchange of information. The team collaborates on a regular basis using communication tools to discuss emerging insights, share feedback information and provide cross-component collaboration.

2. **Information gathering about the group and the activity**: Information gathering must take place for information acquisition. Team members engaged in a new project for an organization might access information resources to learn lessons from similar projects, access relevant information during project implementation to find solutions for problems, and access relevant information afterwards for advice on after-project actions and review activities. Besides retrieving formal information individuals have to gather information from experts on an ad hoc basis. Information gathered from experts is rich in content and suitable for the problem being addressed and suited for people who addressing it. However, you cannot capture an expert’s insights and experience for future use which results in problems when the expert becomes unavailable or a new solution is required for a new issue. More recently social computing tools such as blogs and wikis have developed to provide a more unstructured, self-governing approach to the transfer, capture and creation of information through the development of new forms of community. These tools face challenges in filtering meaningful re-usable and intelligible information and ensuring that their content is transmissible through diverse channels, platforms and forums. Social computing is defined as any type of computing application that serves as an intermediary or a focus for a social relation, shifting importance away from traditional technologies such as e-mail (Schuler, 1994). Social computing tools can be used in the creation of new information and the transfer of existing ones within collaborative environments such working groups, organizations or community.

3. **Management of shared access or how information accessed and used**: Information access is different from information exchange because team members may have access to information without exchange it. When information is available on an intranet or, in other words, when access to information is established, this is not a guarantee that information exchange will occur. Management of information sources involves management of different types of resources namely, shared repositories, internal, external, primary and secondary information sources, ensuring the information flow in an organization and ensuring access of team members to relevant information. Management of shared access is critical to ensure the distribution of information through the group and to guarantee that the information distribution remains dynamic and oriented toward the needs of specific groups of information users.

4. Transfer of objects and tools between team members to make sure that the task is divided, or roles are switched so that they can achieve the task. This implies two activities: handoff (when an object or tool is transferred) and deposit (when a resource is put in a particular place to retrieve it later) (Bouthillier, & Shearer, 2003).

d. A team collaboration model proposed by Warner, Letsky, & Cowen (2004) focuses on macro-cognition and based on information management processes it provides a better context to evaluate collaboration tools, because there is empirical support for their collaboration stages. The model has four unique interdependent stages of team collaboration. Each stage has its own requirements for
work tools and environmental support; what helps at one point in the team’s life cycle can hinder at another. These four stages are:

1. Team knowledge base construction.
2. Collaborative team problem solving.
3. Team consensus.
4. Outcome evaluation and revision.

Before we discuss in details each of these stages, we want to know what the inputs for that model are.

**Model Inputs**

The inputs represent general information that is required before team collaboration. This information includes (Warner, Letsky, & Cowen, 2004):

1. A description of the problem to be solved.
2. Team member expertise.
3. Organization structure.
4. Team members’ roles and responsibilities.
5. Projected events or future information.
6. Resources available.
7. Supporting collaboration technology.
8. Information certainty.

**First Stage**

Which is the team knowledge base construction where team members begins by identifying the relevant domain of information required, setting up the communication environment necessary to address the problem, selecting team members and manager, and developing individual and team task knowledge. As mentioned previously, team members should represent a mix of information practitioner communities (e.g., information management, records management, web management, libraries, knowledge management and IT), culturally diverse, having heterogeneous knowledge as well as the technical units of the organization.

This stage has three processes (Warner, Letsky, & Cowen, 2004):  

a. **Meta-cognitive process:** Teams with the needed communications connectivity can collaborate effectively if individual team members know what they need to know to develop member’s understanding of the elements, relations and conditions that compose the problem. Teams whose members lack this knowledge are prone to various kinds of predictable collaboration problems. Knowledge is central to collaboration and teamwork (Wegner, 1987).

b. **Information processing tasks:** Human collaboration depends on collecting and exchange information to identify the problem to be solved and to understand the problem task. Researchers have sought to understand the potential relationships between information and team performance (Larson, & Christensen, 1993; Grant, 2000). Team members typically tend to proactively seek new
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information to achieve their joint goals. Some psychological studies about high performing teams have identified the ability to proactively offer information needed by team members as one of the key characteristics of effective teamwork (Dickinson, & McIntyre, 1997; McIntyre, & Salas, 1995; McIntyre, 1995). Proactive information delivery occurs more frequently when human teams need to filter and fuse an overwhelming amount of information and to make critical decisions under time pressure. Because of the large amount of information available, collaboration teams are often faced with information overload. Much of that information comes from open sources such as the internet. As a result, information uncertainty becomes a primary concern. In addition, some information such as government intelligence is dynamic in nature, and is, therefore, constantly changing. In this case, continually monitoring the flow of information to ensure accurate and timely mission planning and execution becomes mandatory (Warner, Letsky, & Cowen, 2004; Warner, Wroblewski, & Elizabeth, 2004). For instance, applications for dynamic domains often require a large number of intelligent agents and human agents to form a team to cooperate effectively in information gathering, information fusion and information delivery for making better group decisions. Information fusion is used to combine information from different sources in order to facilitate their integration. The collected information may contain a huge amount of useless information which must be removed before it can be verified and stored. Information filtering is used to remove information outliers and construct the team's knowledge base.

c. **Knowledge required:** Knowledge and understandings are usually distributed among members of a team. Everybody does not need to know everything for a team to be effective. But every team member does need to know how to get the knowledge he or she needs to develop his or her individual knowledge to carry out the task, e.g. the knowledge to support “task work”. The team has to establish a combined representation of the team’s knowledge of the task, which is the knowledge required for the team members to work together effectively; e.g., the knowledge to support “teamwork.” (David N., 2002).

**Communication Mechanism for Knowledge Building and Information Processing**

For the team to build the required knowledge base needed the team will use the following information management processes (Warner, Letsky, & Cowen, 2004):

- a. Information gathering
- b. Information retrieval
- c. Information fusion or integration
- d. Information organization
- e. Information display and visualization
- f. Information filtering

**Specific Communication Mechanisms Between Team Members**

These mechanisms include (Warner, Letsky, & Cowen, 2004):

1. **Presenting individual information:** An individual can use tables to present his information. Tables display key information usually numbers and can form a summary of information, or they
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may be a starting point for a negotiation. Percentages, rather than actual numbers, are used to compare between different information groups. Diagrams are a common graphical way of presenting information. Processes and ideas can often be summarized more effectively in diagrammatic form than in words.

2. **Discussing individual and team generated information and possible solutions**: These discussions lead to share ideas and reference documents, stimulate valuable peer-to-peer discussion among decision makers. Create a positive collaboration culture in which team members present their thoughts and gather opinions on how to progress their thinking and in turn improve solutions.

3. **Negotiating perspectives**: Team members should get more accurate information about the problem, tasks and the proposed solutions before negotiation to allow them to make choices and decisions. Transparent and accurate information flow between negotiators of the team elevates the effectiveness of team production such as team assessments, plans and solutions. Also, negotiation creates explicit rules for operations and routines for management and hence has a direct impact on team collaboration. Team performance is expected to benefit from negotiation.

4. **Questioning**: Questions are designed to support monitoring tests of the proposed solutions, so that teams can spot opportunities to engage in collaborative critical thinking and avoid needless debates.

5. **Agreement**: An agreement between team works will deepen their information exchange on a confidential basis, enables them to accessing documents, formalizes and strengthens the ongoing collaboration between them. An agreement represents a valuable coordination of the roles of team members to better perform their responsibilities. In case of exchanging confidential information, a receiving team should maintain the security of this information using a reasonable standard of protection, and no less than the standard of protection taken to protect his own confidential information, and will use such confidential information solely for the purposes of implementing his assigned tasks in the collaboration agreement. When confidential information is no longer required for purposes of a collaboration agreement and continued use of confidential information is not provided for another collaboration agreement, each receiving team should return or dispose of any tangible records of confidential information.

6. **Disagreement**: Team leaders and members use disagreement within the group as an indicator for conflicting interpretations should be resolved, that the relevancy and accuracy of assumptions and paradigms should be tested, and that uniquely held information should be shared. Disagreements are pointers to uncertainty in the assessments and plans the team generates. Proficient teams use disagreement as an indicator when they monitor the need to engage in collaborative critical thought (Jared, & Kathleen, 2003).

The following collaboration capabilities are required to facilitate the team using the above mechanisms during this stage are (Warner, Letsky, & Cowen, 2004):

1. **Explicit communication**: Explicit communication can significantly multiply the capabilities and effectiveness of team works. It requires explicit signaling and reception of the communicated information. It refers to the things we say or write, often messages intended to influence the behavior of others (Robert, 2007)
2. **Information exchange**: Team members should be able to exchange information freely with other team members either upon request or spontaneously. This exchange should produce any available information that may be relevant to an analysis or investigation of the problem and other relevant information and the persons or work teams involved. Information exchanged between individuals should be used only for the specific purpose for which the information was sought or provided.

3. **Conventions for information exchange**: Exchange information with the others should be on the basis of reciprocity or mutual agreement and consistent with procedures understood by the requested and requesting party. A party requesting information should disclose, to the party that will process the request, at a minimum the reason for the request, the purpose for which the information will be used and enough information to enable the receiving party to determine whether the request complies with its domestic law. Information exchanged between parties may be used only for the specific purpose for which the information was sought or provided.

The requesting party may not transfer information shared by a disclosing party to a third party, nor make use of the information in an administrative, investigative, prosecutorial, or judicial purpose without the prior consent of the party that disclosed the information (Egmont Group, 2001).

**Second Stage**

Which is the collaborative team problem solving where the majority of collaboration occurs among team members. This stage also includes three processes (Warner, Letsky, & Cowen, 2004):

a. **Meta-cognitive process**: Where the team develops a mental representation of how to solve the problem. This stage includes three related mental process:
   1. Selective encoding where information filtering process is used to revise the collected information to eliminate more irrelevant information.
   2. Selective combination where information fusion process is used to put together elements of the problem or the task.
   3. Selective comparison where data mining processes can discover non-obvious relationship between new information and information acquired in the past. Using information exchange the team gains more complete understanding of task elements, goals or overlooked information.

b. **Information processing tasks**: The information-processing model developed by (Bouthillier & Shearer, 2003) suggests a number of activities that would require collaboration and, by definition, information retrieval and exchange.

c. **Knowledge required**: Five types of knowledge are required at this stage (Warner, Letsky, & Cowen, 2004):
   1. Team member has to develop his or her individual knowledge through accessing relative information in the knowledge base. Information filtering facilitates accessing relative information. Information fusion helps a team member integrates between retrieved information from multiple knowledge bases.
   2. The team as a whole has to develop team’s knowledge of the task through information exchange and distribution and integration.
3. The team needs to develop shared understanding of the problem to be solved or the task to be completed. Shared understanding is achieved through the communication of large amount of information and a set of shared information, information visualization, shared beliefs, joint agreements of the facts, perspectives and assumptions that collaborators have.

4. Collaborative knowledge: is an informal type of information which results from team discussions, brainstorming, information exchange and integration, information display and visualization processes which could result in new information which deepens team understanding of the problem and agreement of the facts. The produced informal information should be codified and structured to facilitate information processing sequences.

5. Domain experts are another type of informal information which is needed by team members to complete their task. Interviews, questionnaires and surveys are helpful to collect this type of information. Emailing an expert can be used on ad hoc bases.

Communication Mechanism for Knowledge Building and Information Processing:

In this stage the team will use some or all of the communications mechanisms discussed later to perform knowledge building. The following collaboration capabilities are required to facilitate the team using the above mechanisms during this stage are (Warner, Letsky, & Cowen, 2004):

1. **Agent-based structural collaboration model**: Is a loosely-coupled network of several, autonomous and interacting software agents which are problem solvers that work together to solve some problems being above their individual capabilities. The sum of several interacting agents’ capabilities in a multi-agent system exceeds the sum of its individual parts (Bilek, & Hartmann, 2003). The adaptation of agent technologies to the specific needs and requirements of collaborative work implicitly requires the decomposition of the entire problem solving process into adequate, domain-specific interacting agents.

2. **Information retrieval, fusion and presentation**: The team uses the information retrieval, fusion and visualization processes to reach a shared understanding about the problem at hand which helps the team to build its knowledge base.

3. **Critical thinking and negotiation**: If team members sense uncertainty and the stakes are high they engage in critical thinking about their assessments and plans by negotiating their understanding of the situation at hand, refining their knowledge, and adapting their decision making and planning to the problems at hand. Identify sources of uncertainty (i.e., gaps, untested assumptions, and conflicting interpretations), and reduce or shift that uncertainty disseminate information, testing assumptions, and forming contingency plans before taking action. Negotiation occurs through explicit communication and the reliance on shared information, shared interpretations of information patterns, and standardized responses to those patterns(Jared, & Kathleen, 2003).

4. **Knowledge retrieval among team members**: Perceived interdependent information sharing, information retrieval within a team’s knowledge network and perceptions of knowledge interdependence affect members’ satisfaction with the team’s overall performance (Palazzolo, & Clark, 2007). Information sharing between team members enhances existing collaborative processes, introduces more efficient and effective collaborative processes and removes redundant processes.

5. **Identification of team differences**: The aim of team identification is to encourage dissimilar individuals to behave according to team norms and conventions, in order to gain acceptance in the
team (Branscombe, Ellemers, Spears, & Doosje, 1999) and to mitigate the negative effects of diversity. At the team level diversity refers to the amount of variance in demographic e.g. age, gender, professional background characteristics or values. Research into dissimilarity provides insight into an individual’s experience of being different from other team members, and how these differences affect their individual behaviors and attitudes (Chattopadhyay, 1999; Jackson, Brett, Sessa, Cooper, Julin, & Peyronnin, 1991; O’Reilly, Caldwell, & Barnett, 1989; Tsui, Egan, & O’Reilly, 1992). Mary (2007) posed the following questions about conflicts within team members: how frequently team members disagree about the content of the team’s decisions. How frequently were there disagreements about the ideas generated by the team? How often were there differences of opinion in the team? How often did people in your group disagree regarding the group’s decisions cohesion? The answers to these questions provide a picture of the team cohesion or dissimilarity.

6. **Joint information visualization**: Is a collaboration visualization using the visualization techniques in order to display shared information between team members; information from different resources is fused together and joint visualization helps to combine all this information for interpretation it is indispensable to share visualization results (Suzuki, Matsumoto, & Sai, 2004).

7. **Hidden knowledge elicitation**: Much expert knowledge is implicit and difficult to articulate and express directly. In order to address the problems of implicit and hidden knowledge, the knowledge engineering community has borrowed techniques from experimental psychology, designed to access internal mental structures. These techniques, termed indirect knowledge elicitation techniques which are: repertory grid analysis, multi-dimensional scaling, and hierarchical clustering. These techniques are used in situations where it is difficult for the expert to articulate their knowledge in response to direct questions (Hudlicka, 1996).

**Third Stage**

Is team consensus and begins after the problem has been identified and team members exchange ideas to clarify issues and have several solution alternatives to the problem. The main objective of team consensus is to reach consensus to decide which steps to use to achieve team agreement of the common output. This stage has also three processes (Warner, Letsky, & Cowen, 2004):

a. **Meta-cognitive process**: Includes team keep tracking of what they have done, what they are currently doing and what need to be done in the future.

b. **Information processing tasks**: Team negotiation is performed through the information presentation of solution alternatives and exchange comments and beliefs in order for the team to achieve agreement of the common output and to develop a unified team mental model.

c. **Knowledge Requirement**: Two types of knowledge are required to achieve convergence of the team’s mental model and successful negotiation of solution alternatives:

1. **Shared understanding**: It is a shared knowledge base required for cooperative problem solving which contains knowledge of a problem or domain that is common to team collaborators. The knowledge contained in the shared knowledge base does not have to be explicitly communicated.

2. **Collaborative knowledge**: It is an informal type of information which results from team discussions, brainstorming, information exchange and integration, information display and visualization processes which could result in new information which clarifies and deepens
team understanding of the several solution alternatives to the problem. The produced informal information should be codified and structured to facilitate information processing sequences.

Communication Mechanism for Knowledge Building and Information Processing

In this stage the team will use some or all the communication mechanisms mentioned earlier in this chapter. The following collaboration capabilities are required to facilitate the team using the above mechanisms (Warner, Letsky, & Cowen, 2004):

1. **Visual representation of the team’s mental model:** Mental models vary somewhat, but are generally viewed as organized and integrated memory structures used to comprehend a given phenomenon (Johnson-Liard, 1983). Regardless of the exact nature of a mental model, visual representations play a crucial role in shaping and communicating mental models. Researchers suggest that, because diagrams are external and often analogical representations of information presented in the text, they may facilitate the development of mental models associated with the content of that text. Visualization support negotiators’ convergence of perceptions of reality and has positive socio-emotional consequences in terms of increasing cohesiveness. As a result, groups with visualization support reach consensus more easily and are more satisfied with the process (Roderick, Tom, Peter, Marius, & Adrie, 2002).

2. **Agent based identification of team differences:** Team members in general differ in their skills and in the way they perceive the external environment. One of the key assets of based identification of team differences is that agents simulate as faithfully as possible, all that is known or inferred about the behavior of human collaborators and their actions in collaborating sessions with their suitability to adapt themselves to any individual’s particular skills, knowledge and personal characteristics. This adaptability can be only reached through a proper human collaborator modeling by every collaborator agent. The basic view underlying the agent-based identification team differences is that agents are embedded in a social frame that regulates their behavior. This social frame, called role space, is composed of roles which are available to the agents and through which an agent can try to achieve individual and joint objectives either alone or in collaboration with other agents. An agent may own several roles and a role may be owned by several agents at the same time. Roles serve as a means for specifying desired behavior and for achieving behavioral predictability, but not as a means for making sure that agents do not exhibit unexpected and undesirable behavior. In particular, roles do not fully constrain individual behavior, but leave room for individuality (Gerhard, Matthias, Michael, & Felix, 2004). With that, system designer can explicitly specify the limits within which human collaborators simulated by collaborator agents are supposed to act and to predict the expected differences between human collaborators.

1. **Joint information visualization:** Is a collaborative visualization using the visualization techniques in order to discuss experimental results or simulation results of alternative solutions in the joint research between remote locations; information from different resources is fused together and joint visualization helps to combine all this information for interpretation, it is also indispensable at this stage to share visualization results (Suzuki, Matsumoto, & Sai, 2004).
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2. **Infrastructure for negotiation:** The infrastructure supporting negotiation between collaborators within work teams requires combining different technologies, such as software engineering techniques, middleware-level coordination facilities and multi-agent systems support.

**Fourth Stage**

It is outcome evaluation and revision which is the final stage of collaboration. The main objective is to analyze, test and validate the agreement upon team solution against the goal requirements and exit criteria. Included in this stage is an iteration loop for deriving other solutions for the problem if necessary.

This stage has also three processes (Warner, Letsky, & Cowen, 2004):

a. **Meta-cognitive process:** This process involves comparing problem solution against the goals. Information display and visualization is important in this stage to present the solution against the goals. Also, information exchange is required to negotiate these results.

b. **Information processing task:** In this process the team analyses and revises the problem solution if necessary. Information retrieval, exchange and visualization processes are required.

c. **Knowledge required:** Two types of knowledge are required:

1. **Goal requirements:** Goals for a desired system are often not clear at the outset they must be extracted from diverse sources of information. It is important to gather as much information as possible in order to obtain a broad understanding of the domain, organization, process and system. A team must have the ability to store, share and display this information for the purpose of identifying, organizing and classifying goals. It is unreasonable to expect to produce a complete set of goals for a system from only one information source. Fusion or integration of various information sources produce a more complete set of goals especially if they incorporate the analysis of both the current and desired system. Goal information must ultimately be translated into requirements specification. A requirement places a condition on the achievement of a goal. A precondition must exist for the achievement of a goal to be possible. The post-condition characterizes the state of the system once the goal is completed. These are done by consolidating the goal information into a set of goal schemas. Goal schemas specify the relationships between goals and agents in terms of events that cause a change of state. Agents are the entities or processes that seek to achieve goals within an organization or system based on the implicit responsibility that they must assume for the achievement of certain goals (Annie, 1996).

2. **Exit criteria for viable solutions:** Are the criteria or requirements which must met to complete a specific process. When testing the product of a proposed solution, a set of test specifications are created to test these products to ensure that it meets minimum acceptable operational specifications. This test specification will state the minimum criteria necessary for the testing process to be considered complete and the products are of acceptable quality.
Model Output

The output of the model reflects the type of product from team collaboration process. The product type will vary depending on the problem domain addressed by the team.

The product types are (Warner, Letsky, & Cowen, 2004):

1. **Selected course of action**: Shared understanding among team members with regard to the impact, importance, and quality of relevant information items such as sensor outputs, text documents, images, messages, and Web pages is a critical element in the selection of an effective course of action (Michael B., & Robert A., 2005). It is important to decide what the minimum information that needs to be exchanged for shared understanding to occur, how do we capture that information and how should it best be displayed or visualized.

2. **Recommendations**: Are team suggestions given to the users to help them solving a problem or to implement a proposed solution.

3. **Situation awareness**: Is an important element to support responses and decision making for problems. Decision making for a complex situation often needs a team to work cooperatively to get consensus assessment for the situation. Team situation assessment is characterized including information sharing, opinion integration, and consensus situation assessment generation. In the meantime, various uncertainties are involved in team situation assessment during information collection and awareness generation. Also, the collaboration between team members may be across distances and need web-based technology to facilitate it (Jie, Guangquan, & Fengjie, 2008).

4. **Risk assessment**: Is the ability and motivation to look ahead and to handle risks before they become problems. Provide feedback information both internal and external to the project on the risk activities, current risks, and emerging risks. Identifying changes and group risks, quantity impact, probability, and time frame and set program priorities to arrive at a joint understanding of what is important. Processing risk information into decision-making information to determine what is important to the project, to set priorities, and to allocate resources. Communication occurs formally as well as informally.

5. **Product or tool**: A team work may recommend a product or tool to solve a problem or to implement a proposed solution.

6. **Opinion**: Team members often want to exchange opinion on their files or on the project as a whole. Email is one way to do this.

7. **Guidelines**: These guidelines are intended to assist and guide members in the workplace in relation to specific issues. They specify requirements to implement a recommended solution on a specific problem. Guidelines are also intended to complement the development of local workplace policies and protocols on professional issues. Draft guidelines are developed by the work team and subjected to internal comment and review by team members, and then they are submitted to the team leader for approval before becoming available to the upper management.

**FUTURE TRENDS**

IBM predicted five future trends that will increase demand for the fast growing unified communications market and reshape the way businesses and workers communicate and collaborate worldwide.
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These five future trends as stated by IBM are (Bill, 2008):

1. The collaborative virtual workplace will become the rule where teams can communicate, collaborate, and share information, regardless of their geographic location. Social networking tools and virtual world meeting experiences will simulate the feeling on being there in-person. Work models will be changed to encourage work at home to reduce travel.

2. Instant messaging and other real time collaboration tools will become the norm. As the email became a necessity instant messaging will be the preferred method of business interaction. Skype is a good example of a tool for instant messaging and voice over IP.

3. Interoperability and open standards will destroy the barriers between business and public domains and force unified communications providers to embrace interoperability. This will help businesses and persons to better find appropriate resources thus removing inefficiencies from business processes and daily lives.

4. Companies will tend to deep integrate with business processes and line-of-business applications where they can realize the greatest benefit. For example, Skype makes efforts to integrate its product with other software applications such as Microsoft Outlook or Mozilla FireFox, where users can use an integrated toolbar to locate the sender of an e-mail or a person whose Skype ID is mentioned on the web (Ned, 2008).

5. New meeting models will emerge and the definition of meetings will be radically changed and become increasingly ad hoc and instantaneous based on context and need. Virtual reality technology will deeply impact online meeting experiences to deliver more life-like experiences to next generation collaborators who will operate efficiently in the familiar environment.

Currently there is no generalized model of human collaboration that combines the various collaborative services and provides a common language and framework for those seeking to better understand and expand the collaborative aspects of any given field of human endeavor. Such model would provide a body of knowledge for those developing collaborative software and other design based enterprises to draw on. The generalized model should include both qualitatively and quantitatively the team social behavior such as motivation, the way people interact, emotional information and issues of cultural change and a willingness to share and collaborate with colleagues which is not included in the current team collaboration models, despite it has a significant effect on human collaboration with team work. The field of human collaboration is now mature and a standardization of its metrics is required. A standardized collaborative index to evaluate the quality of team collaboration at each of its stages is required. We propose a metric called the collaboration coefficient to measure the degree of collaboration between working groups. This coefficient ranges from 0 (no collaboration) that is team members are working in isolation all the time to 1 (full collaboration) that is team members are working in collaboration all the time. This measure is simple:

\[ \text{Collaboration coefficient (CC)} = \frac{\text{Total time spent in collaboration}}{\text{Total time of the project}} \]

For example, if a work team is composed of three members say i, j and k then the collaborative coefficient is measured as follows:
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\[ CC = \frac{T_{ij} + T_{jk} + T_{k} + T_{ijk}}{T} \]  \hspace{1cm} (1)

\[ T = T_{ij} + T_{jk} + T_{k} + T_{ijk} + T_{i} + T_{j} + T_{k} \]  \hspace{1cm} (2)

Where

\[ T_{ij} \]: time spent in collaboration between \( i \) and \( j \).

\[ T_{jk} \]: time spent in collaboration between \( i \) and \( k \).

\[ T_{ij} \]: time spent in collaboration between \( j \) and \( k \).

\[ T_{ijk} \]: time spent in collaboration between \( i, j \) and \( k \).

\[ T_{i}, T_{j}, T_{k} \]: time spent by members \( i, j \) and \( k \) working in isolation respectively.

\[ T \]: time spent to complete the whole project.

Our measure differs from that mentioned by (Ajiferuke, 1988) in that our collaboration coefficient depends mainly on time as a factor for measuring collaboration while that used by Ajiferuke depends mainly on the number of collaborators in a project. We believe that a combination between the two measures will give a more realistic value for collaboration. It is important to discuss if there is an optimum collaboration size for how many collaborators working together? If so, what is this size? This metric is also a measure for the complexity of the potential division of labor and communication channels (March, & Simon, 1958), as well as the difficulty of monitoring team members; information security becomes particularly problematic as collaboration size increases (Baker, & Faulkner, 1993). We believe that if the number of collaborators exceeds the optimum number then some of the team members can be non-productive or impeding. A standardized metric to measure the degree of group cohesion is important in team collaboration. As the group becomes more diverse, it becomes increasingly difficult to count on shared understandings to solve problems as they occur (Rothschild-Whitt, 1979). It is important to develop guidelines for selecting the right team members, providing the right kind of training, and selecting the right types of collaboration tools to improve team collaboration.

CONCLUSION

In this chapter we have showed that the hierarchical organization is more efficient for the management of information processes rather than other alternative organizations such as flat, linear and network organizations. We also showed that using the hierarchical organization facilitates information retrieval through the efficient classification of information topics.

The hierarchical organization is efficient in information gathering, and it is the best for both information routing and large scale networks. The problem of information overload is efficiently reduced through building information filters and bookmarks that are organized hierarchically. In information organization hierarchical bookmarks facilitate organizing the information on the World Wide Web also people are familiar with the hierarchical organization and can easily understand the hierarchical relationships between information topics. The hierarchical organization makes adding, modification or deletion of information topics efficient and guarantees their integrity and consistency. We showed the hierarchical organization facilitates information feedback through a cyclic bottom-up and top-down operations.
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through examples from our daily life and from the field of artificial intelligence where the performance of artificial neural networks increases if it is organized hierarchically and applied the feed forward back propagation learning algorithm. In information fusion the hierarchical organization increases the fidelity and availability of information within the organization. In problem decomposition the hierarchical organization simplifies a large problem by dividing it into well defined sub-problems which are solved at the lower level and the solution is reassembled at the higher levels. Also, hierarchical organization facilitates information exchange across the hierarchical levels of the organization and across the Internet using multi-agent based systems. In information visualization we showed the hierarchical organization is very effective in displaying hierarchical information, Web pages and multidimensional information organized hierarchically. In human collaboration, we showed that information management improved the interaction between team members at the four collaborative stages of the cognitive collaboration information based model. In the first stage the team collects and exchange information to identify the problem to be solved and to understand the problem task. In the second stage the team needs information filtering, fusion or integration and data mining processes to develop a mental representation of how to solve the problem. Each team member has to develop his or her knowledge through accessing relative information. The team as a whole has to develop its knowledge and reach a shared understanding through information exchange. In the third stage the team is trying to reach a consensus about a solution therefore they need to exchange ideas and display information. Two types of knowledge are required in this stage which is shared understanding and collaborative knowledge. The fourth stage is outcome evaluation and revision, two knowledge types are required which are goal requirements and exit criteria for viable solutions.

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**KEY TERMS**

**Distributed Collaboration**: It is a form of online collaboration where team members work in an asynchronous environment.

**Flat Organization**: It is an organizational structure with few or no middle management between staff and managers thus bringing top management in direct contact with staff and customers.

**Hierarchical Organization**: It is a pyramid like organization where the top node is called the root under which there are one or more subordinates. The higher level nodes have domination and superiority over the lower nodes.

**Human Collaboration**: It is the process of working together, especially in a joint intellectual effort.
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**Information Classification:** It is the process of arranging information topics in a hierarchical organization that are related by parent-child relationships.

**Information Creation:** It is a process that includes collecting data from observation, experts, sensors and data analysis results.

**Information Filtering:** It is the process of finding the most interesting and valuable information so people can avoid the problem of information overload.

**Information Flow:** Is the transfer of information between team members in a collaboration process or between individuals at different levels of a hierarchical organization in a communication process.

**Information Fusion:** is integrating information from different sources in order to facilitate understanding or provide knowledge that is not evident from individual sources.

**Information Gathering:** It is the process of collecting as much information as possible about a problem through problem analysis and search activities in information sources.

**Information Management:** It is the discipline for collecting, organizing, filtering, retrieving, distributing of information with a goal of efficient management.

**Information Organization:** It is the logical arrangement of information topics in a file system.

**Information Processing:** It is the process of gathering, organizing, storing, retrieving and using of information.

**Information Retrieval:** It is the process of searching information topics within documents, in relational databases and on the World Wide Web.

**Information Visualization:** It is the process of converting data into a geometric or graphic representation to create visual images that aid in understanding complex information.

**Knowledge Building:** It is the process of creating new knowledge.

**Knowledge Management:** It is the discipline used by organizations for gathering, organizing, sharing, and analyzing what it knows.

**Meta-Cognitive Process:** It refers to individual awareness of what he needs to know to develop his understanding of the elements, relations and conditions that compose the problem.

**Network Organization:** It is an organization structure where every node is connected to any other nodes arbitrarily without any constraints.

**Online Collaboration:** Team members working in different locations at great distances apart.

**Team Collaboration:** It is the process in which team members working together, sharing information and ideas and negotiating in attempt to reach a shared understanding of a situation.