Working Paper # WP-11-2020

April 10, 2020

Multi-Level & Multi-Team Coordination in Real Time: Food and Emergency Response Challenge for COVID-19

Dr. Ejaz Sandhu

Multi-Level & Multi-Team Coordination in Real Time: Food and Emergency Response Challenge for COVID-19

By Dr. Ejaz Sandhu

1. Introduction

The environment in which we as human being interact is becoming increasingly complex, therefore the efforts and the amount of information needed for a good decision making process has increased many folds. The issues have critical importance for all service providers, especially those working in emergency services, security and defense. Use of computers and automated equipment has helped in resolving these issues, but as we move towards still higher complexity the options available to the agents in such a complex environment and the outcome of these actions are becoming infinite.

The Government of Pakistan has announced that a large number of volunteer force namely "Tiger Force" shall be deployed to help in providing food at the doorstep of the needy population, but ground experience has shown that requirement assessment and coordination between multi-terms shall be the largest challenge facing these efforts. The proposed solution is designed to answer the above challenge.

The proposed solution is based on the finding of research in high performance teams taking into consideration group interaction, as centerpiece of group activity for achieving higher degree of performance. It is deliberated that Mental model plays a fundamental role in developing team cognition. The Team cognition includes mental process and experience of knowing e.g. perceiving, recognizing, conceiving, and reasoning (i-e view of reality of a team).

The members of a team can only work as a team if they have similar mental models. The team members which may be humans or AI agents (software, robots) are integrated in the team according to their role outlined in the mental model. Whereas the role played by each team member is dependent on the level of consciousness of that team member.

Philosophical grounds: A paradigm shift in system designing perspective is needed to enable high level of Human-to-Human Team coordination. Contemporary efforts to develop high coordination in teams are not being successful because team coordination

schemata is developed without identifying a common axis on which the team members/agents can be aligned and later on synchronized.

The proposed system rests on some basics which are outlined as under.

1. A pragmatic team mental model is needed that shall enable humans and artificial agents (computer, software, robot) to work in a synchronized holistic system.
2. The hybrid teams developed must have a common axis on which the agents can be aligned and later on synchronized.
3. The consciousness level of an agent (human or a machine) determines the role that an agent can play in a team.

Presently computers cannot perform activities requiring high level consciousness as these systems presently lack higher consciousness that is found in human agents. The computer controlled systems would need to develop artificial consciousness before they are able to be integrated on higher level in such hybrid teams.

2. Cognitive Framework (Mental Model)

Mental model refers to a person's mental representation of a system and how it works (Johnson- Laird, 1983; Rouse and Morris, 1986). This definition takes into account (1) the variables included in the system, (2) the properties and states of those variables, and (3) the causal or other relationships among those variables. These mental models have so far been limited to shared mental models, situation mental models, transitive memory system, task mental models etc.

Shared mental models extend the notion of individual mental models to a team context. A shared mental model explains a coordinated behavior that produces a mutual shared awareness, with which team members can reason not only about their own role with regard to situation, but also the status and activities of the other team members in the pursuit of the joint goals (Cannon-Bowers et al., 1990; Rentsch and Hall 1994 and Porter et al., 2003). Shared mental models also explain dynamic adjustment of team members while anticipating the need and the task of the team member.

Based on the study of literature, in the domains of cybernetics, team management, team coordination, knowledge based management of teams, and more specifically group cognition. A new mental schema, Cog-synergy fig-1 is presented, with the purpose to enhance group's accurate understanding of the mental models of other members.

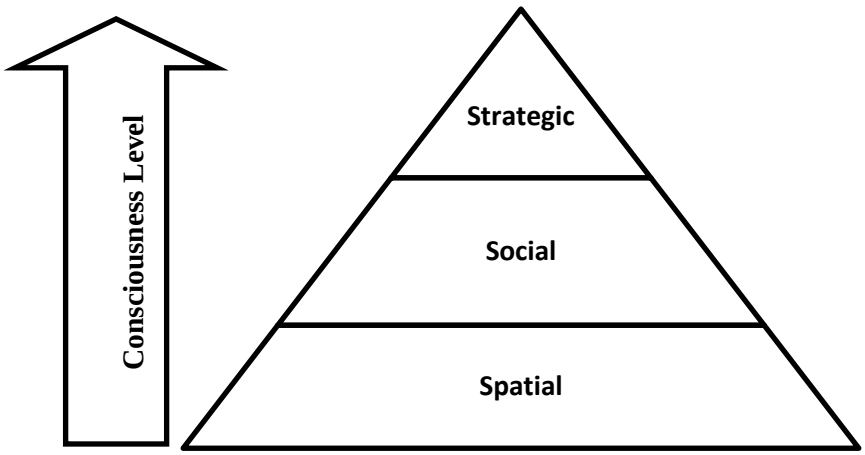

Figure (1)
Cog-Synergy Model (Khan et al., 2011)

It is argued that any task no matter how big or small in dimensions can be viewed as an overlap of three cognitive levels, which are spatial, social and strategic levels. The strategic level contains the vision and purpose for which a certain task has been undertaken; this strategic vision should be aligned with the overall, vision of the system. The second layer is the social layer, this determine the social laws that are governing the system. These laws may consist of a contract between an employee and an employer, rules of business (business model), constitution of a country, rules of international trade, family values or even a religious dogma. Therefore all interaction that is taking place in a system follow these laws, however the governing laws may be formal or informal is another issue. The spatial layer in the model is where all observable action is taking place, agent's behavior and interaction with other agents in the system and the environment takes place in this layer. The layer contains all tangible measures like length, breath, height, mass, time, temperature, force, financial units etc.

The model proposed in recursive in nature, applying that same mental model is applicable on a single agent as well as a group of agents interacting with one another and even between large groups interacting within one another.

3. Developing Human-Machine Teams

The Human-Machine teams can be developed using Cog-synergy model as a reference. The role played by each team member shall depend on the cognitive capacity of the agent. Table (1) gives a summary of the typical roles that human and AI agents can perform in a

hybrid team. It would be noted that AI agents have not been given independent or a leading role in any of the layers, which is because the present AI developments are not mature enough for such roles. However autonomous role with a limited scope can be given to AI agents in spatial layer.

Table (1)
Roles played by agents in a Human-Machine Team

Coordination levels	Role played by human agents	Role played by ICT and AI agents
Strategic Level	• Determine the vision and mission • Determine the goals for the system • Modify strategic directions as needed	• Provide output to Human agents based on 1. Advance data analysis 2. Scenario planning using game theory etc.
Social Level	• Determine action required based on the following information 1. Input by AI and other agents from Social and Spatial layer 2. Goals provided by Strategic layer players	• Provide output to Human agents based on 1. Software that may do human agent profiling 2. Group/ Community profiling 3. Law expert systems
Spatial Level	• Determine action required based on the following information 1. Input by AI and other agents from Social and Spatial layer 2. Goals provided by Strategic layer players	• Perform robotic actions as directed by human agents • Provide output to Human agents based on 1. ERP systems 2. GIS Guiding / Monitoring systems 3. GPRS enabled systems 4. Data analysis 5. Data warehouse

The roles of the player presented in table (1) are generic in description and the actual roles that a task or a project shall be utilizing will depend on the nature of the task. Higher level roles for AI agents in their present stage of evolution would be too early.

4. Discussion

The mental model presents a generic description for a system that is using ICT for team coordination. Specific systems that may be developed to provide security or other emergency services would have to be designed to meet specific system needs. However the guiding rules for developing such a system shall remain the same.

Scalability: The system proposed in designed on self-controlling teams, therefore the system can be expanded or deduced to optimum performance as needed.

Easy recruitment and training: The training of the team members would depend on the specific system designed, but other than that no additional training would be needed by human agents to integrate them in the team.

Cost-effective: The cost effectiveness of the system shall differ according to the specifics of the system that is build.

No-new technology to invent: The system is designed in the view of present technological advancements. The foundation of the system is developed on intranet/ internet depending on the requirements, the number of servers and client used would also depend on the scope of the system.

Repeatable: The system design principles can be used in similar projects.

Originality: The team mental models developed earlier could only work at a single layer level, therefore the previous mental models were useful in situations with limited scope, but as the environment is becoming more complex, the mental models required to synchronize teams need to evolve to a higher level. These new mental models need to ensure that the teams are synchronized on all levels. The mental model presented here is the first of its type, which develops synchronization in team cognition in spatial, social and strategic layers.

5. Use Case

Recent challenge that Pakistan is facing in the form of Covid-19 and the most difficult task is to provide food and emergency response to the large section of poor population

living in congested space and larger cities. In addition to this, there will be real danger of riots taking place in the areas where volunteer force would be working on ground. Such fast and dynamic situations demand that public service organizations should be ready for a quick, timely and synchronized response. The large number of population involved in such cases makes it very difficult for organizations to evaluate situation and respond appropriately. Technology can provide very effective solutions in this situation, the use-case discussed in this section employs Cog-synergy mental model to synchronize emergency relief efforts in a hypothetical scenario.

Scenario: Let us suppose that a large part of population needs to be provided food due to implementation of lockdown requirements, while there are some places where medical care needs to be provided at the same time. There can also be limited riot incidents developing in the city displacing population and destroying major part of the roads and other infrastructure. A situation like this would be a nightmare for any emergency service provider.

Strategic objectives: There is an immediate need to provide food and relief to emergency situation. This demands that a system may be developed to provide immediate relief to the community in a coordinated manner. It should also be noted that there would be a number of organizations Government, local CBO and international aid that could be working in the region.

Team Coordination Framework: The conceptual diagram of the Public & Community Coordination (PCC) Management System is given in fig (2), while the user interface for the system is given in fig (3). The system is developed using the Cog-synergy framework. According to this frame work the emergency response tasks are viewed in three layers, namely the spatial, social / relational and the strategic layers.

The overall planning is handled at the strategic layer; the agents taking part at this level can interact with one another and develop short term/ long-term policies. The ICT/ AI agents that can help humans at this level can be visualized with the help of table (1).

The second layer is the social-layer that would actually organize the planning done in the upper layer. The social-layer coordinates all the rules of actions required for the agents to perform the tasks planned. If rules of engagements between agents or teams does not exist or are insufficient, then these rules must be developed first before getting into any activity.

This layer would contain all international, Local, even social norms linked to a region in which the task is being performed. The role of the AI agents at this level would again be in accordance to their abilities given in table (1).

The third layer namely the spatial-layer is where all observable action will be taking place. Major part of data collection and actions performed by human and machine agents will be in this layer. The most active component of this layer is "Basic Knowledge Unit" (BKU) established at the "Field camp level" meaning that each camp established by the authorities must have a "Basic Knowledge Unit" established as an integrated part of the field camp.

Basic Knowledge Unit shall act as the hub of all field activity in a certain geographical region. All information regarding the needs of the regional population shall be maintained at the BKU. Similarly coordination of activities regarding demands and supply shall be coordinated by BKU. Each BKU shall be registering a number of individual volunteers; these volunteers shall gather and provide the unit with information from the field. The Government facilitation at this level can be provided by the "Tiger force" Community Development Workers of Health, Education or Public Health Engineering Departments of the Government. Regional strategies for rehabilitation of the population will be developed by social workers at BKU level.

The working of each BKU is supported by NGO's and district management at the next higher level. The organizations working at this level can coordinate on vertical level with other such organizations working in the region or on vertical level, where they can reach BKU on lower level or Govt, Disaster Management Cell or International donors on the higher level.

The highest level of the management system shall be dealing with development of strategic directions for handling the catastrophe and coordination efforts at the country level. Strategies developed at this level shall be implemented with the help of NGO's on the lower level.

The Management system developed will be Internet based and available to all registered users with some controlled access areas. The program will provide vertical as well as horizontal knowledge integration with transparency throughout the chain from the community development workers in the field to the highest level of the Management

System. The system will be able to allocate tasks to all volunteers according to their constraints, so that the volunteers have to go through minimum of disturbance.

Technology requirements: The system is developed on internet technology to link maximum number of agents. The spatial-layer should be on wireless connectivity as this layer has to provide connectivity in the field. The wireless connectivity can be established in the remote area to connect agents through handheld devices etc. The social-layers and strategic-layers can be connected with high speed channels over optic fiber or other media. The strategic and social-layer does require higher connectivity and processing speeds due to the higher volume of information that these layers would have to process.

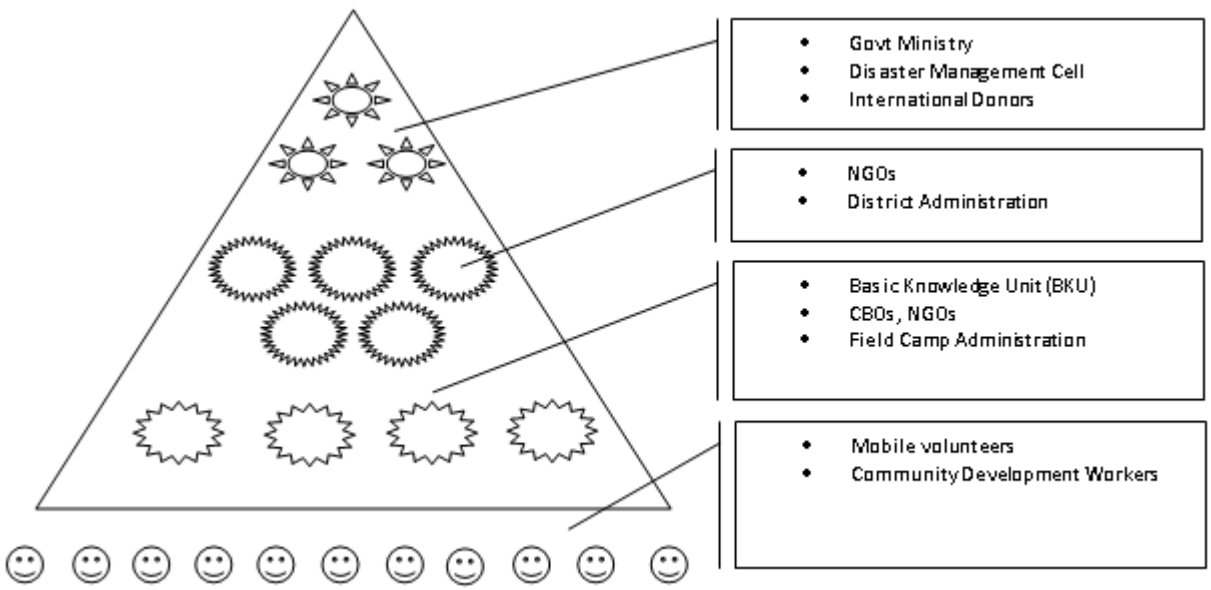

Figure (2)
Conceptual Diagram of Public & Community Coordination Management System

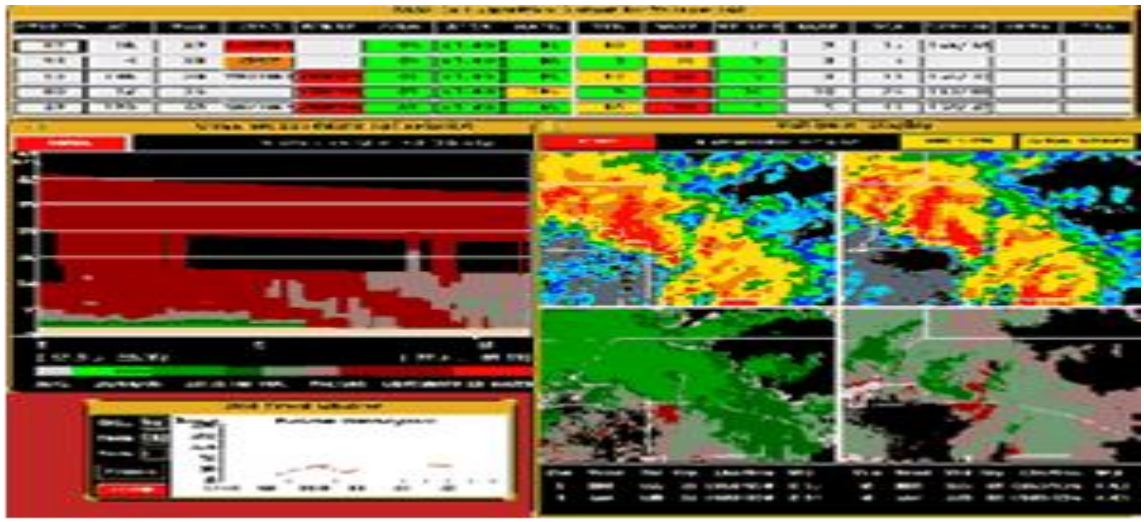

Figure (3)
Graphic User Interface for PCC Management System

References

Cannon-Bowers, J. A., E. Salas, and S.A. (1990) Converse, Cognitive psychology and team training: Training shared mental models and complex systems, Human Factors Society, Bulletin 33, pp 1-4.

Johnson-Laird P. N. (1983). Mental models. Cambridge M. A: Harvard University Press

Khan, M.M., Lodhi, S.A. and Makki, M.A.M. (2011) Cog, Synergy : A model for high performance teams, International Journal of Academic Research Vol 3, No 5, pp 102 – 108

Porter, C., Hollenbeck, J.R., Ilgen, D.R., Ellis, A.P.J., West, B.J. and Moon, H.K., (2003), Towards understanding backing up behaviors in work teams: The role of Personality and the legitimacy of need for backing up others, Journal of Applied Psychology, pp 88, 391-403

Rentsch. J.R. and Hall, R.J. (1994), Members of great teams think alike: A model of team effectiveness and schema similarity among team members, in. Beyerlein, M. M and Johnson, D. A., Advances in interdisciplinary studies of work teams 1, Series on self-managed work teams, Greenwich, CT: JAI Press, pp. 223-262.

Rouse W. B. and Morris N. M. (1986). On looking into the black box: Prospects and limits in the search for mental models. Psychological Bulletin, 100, pp 349–363.