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Conceptual Approach to the Tehran-North Freeway Project from the Perspective of Miller's Living Systems

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Abstract

Having a systematic approach will greatly help stakeholders to know more about the communications, needs, and processes of the project. The approach to living systems that have been expressed by Miller, however, is derived from the field of biology, but due to its dynamic nature, it is also applicable to other fields of science. In this study, we tried to investigate the Tehran-North freeway, an Iranian project from the standpoint of living systems. For this purpose, after describing Miller's approach, a brief description of the mentioned project will be presented in order to model the project flow from two perspectives material/energy and information using living systems. According to the modeling, a good similarity between the living systems and the structure of the project could be observed.

Keywords: Energy, information, living systems, matter, miller, Tehran-North freeway

INTRODUCTION

The living system offers a new approach to looking at the project. Conceptually, we want to have a better understanding of the project specifications that are required for effective implementation. This theory focuses on material/energy flow since comes into the project until the product is made. Furthermore, this theory provides information flow which is needed for the effective management of material/energy flow [1, 2].

Depending on the dynamics of the project, the results will be significantly different. As the project becomes more dynamic, the presented model can better justify the behavior of the project. All the project stakeholders can benefit from this conceptual modeling, especially owners and project managers, and also project controllers [3].

The main steps of this investigation are shown in Figure 1.

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De Witt [4] has explained the system boundary and the influence/effectiveness of the environment. He has considered the system as a limited part of reality, which has internal interconnected parts. Therefore, a border should be chosen for it. With this choice, the system is isolated from its surroundings, which is almost impossible. Therefore, an effort should be made to choose a border where the environment can influence the system, but the influence of the system on the environment is as minimal as possible. In order to achieve this goal, it may be necessary to choose a system that is larger than necessary for general purposes. For example, in agricultural systems, the small-scale climate is mainly a part of the system, but everyone forgets the impact of the agricultural system on large-scale climate, although this is not correct, anyway, the assumption is that everything is related to everything, certainly brings all research to a dead end.

Varela et al. [5] studied the organization of living systems and their characteristics and also presented a model from the point of view of automatic dynamics. According to researchers, biological evidence shows that living systems are a class of automatic dynamic systems. They defined automatic dynamic systems as mechanical systems that are defined by specific organizations in the form of units. Then, by defining 6 key points, they stated the criteria for the automatic dynamics of a specific unit. For example, they pointed out that if the boundary components of a unit are produced from the interaction of its components, this unit can be automatically dynamic. The authors stated their goal in presenting the model is to create a simple visualization of the automated dynamic organization. Their model is important from two perspectives: on the one hand, it provides the possibility of observing the automatic dynamic organization at work in a simpler system than any living system, such as its spontaneous production by the components, and on the other hand, It enables the creation of tools for the analysis and production of automatic dynamic systems.

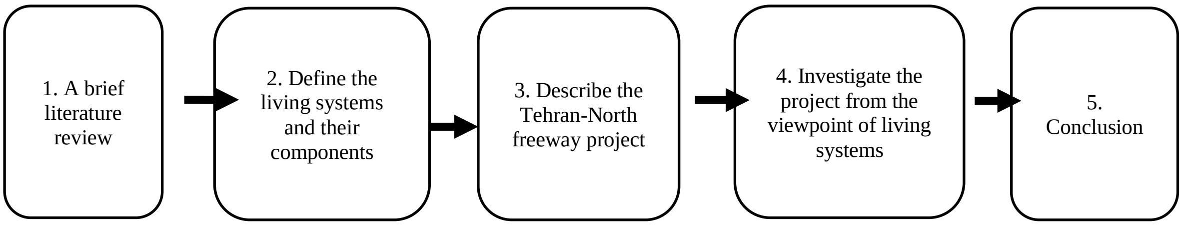

Figure 1. The main steps of this investigation.

In this study, Miller's theory [6, 7] about living systems has been discussed first and the components of his model have been defined. Next, the Tehran-North freeway project is introduced and explanations about its status are provided. In the end, an attempt has been made to examine this project from Miller's point of view (living systems) and compare its components.

Living Systems and Their Components

The general theory of systems is a set of related definitions, assumptions, and proportions that deal with reality and are integrated hierarchies of material and energy organizations. The general behavior theory of systems is related to a special set of all systems (living systems) [8].

Beyond the definition of the system concept are the concepts of "material," "energy," and "information." Because living systems are made of materials/energy that are organized by information.

Materials and Energy

The matter is anything that has mass and occupies space. Energy in physics means the ability to do work. Energy is neither created nor destroyed but can be transformed from one type to another. Therefore, in this research, matter, and energy may be used interchangeably. Living systems need specific types of energy/materials such as heat, lighting, water, minerals, vitamins, foods, fuels, and raw materials in sufficient amounts. The energy required by living systems is obtained from molecular breakdown. Any movement in space from one point to another point is called "action."

Information

"Concept" is an important part of the information within a system that makes it flow. Information is a simpler concept: the degree of freedom that exists in a given situation to choose among signals, signs, messages, or patterns for transmission.

Information stands against uncertainty (Table 1). It is no coincidence that the word "method" appears in information because the information is a part of thought patterns or complexity in any system.

System theory is something beyond information theory. Because it also deals with people's movements; The flow of raw materials in society or the use of energy by brain cells.

Only a small part of the energy used by most living systems is used for information processing. However, it may be the minimum energy required to transmit one bit of information in a particular situation.

Table 1. Mutual concepts in the system [6].

Information	Uncertainty
Negentropy	Entropy
Signal	Noise
Accuracy	Error
Form	Chaos
Regularity	Randomness
Pattern of form	Lack of pattern or formlessness
Order	Disorder
Organization	Disorganization
Regular complexity	Irregular simplicity
Heterogeneity	Homogeneity
Improbability (only one alternative correctly describes the form.)	Probability (more than one alternative correctly describes the form.)
Predictability (only one alternative correctly describes the form.)	Unpredictability (more than one alternative correctly describes the form.)

The movement of matter/energy through space (action) is a type of process. Another type of process is the information process or communication, which is the change of information from one state to another or its movement from one point to another in space.

Communication from A to B needs to express constraints and some dependencies between what happens in A and what is in B. If for a specific event in A, all possible events can occur in B, there will be no connection between A and B. Therefore, the presence of organization among variables is equivalent to the presence of constraints in the production space of possibilities.

The structure of the system is the arrangement of its subsystems and components in 3D space at a given time.

A process is all changes in a system over time of matter/energy or information.

Subsystem and Component

In each system, it is possible to identify a group of units, each of which performs a clear and separate process and has a separate structural part from the other group. The sum of all the structures in a system that perform a unique process is called subsystems. Therefore, each subsystem is known by the process it performs. A subsystem exists in one or more identifiable structural units of a system. These special, local, and distinguishable structural units are called components, or members, or parts. There is no one-to-one relationship between process and structure. One or more processes may be performed by two or more components. Every system is a component but not necessarily a subsystem.

Key Subsystems

Certain processes are required for life, which must be carried out by all living systems. These rescue processes are implemented by some other systems. They are carried out by the following key subsystems:

In the following, explanations about some of these subsystems will be discussed:

Boundary

An important function of boundary processes is to prevent excessive energy loss. A number of groups protect themselves from external tensions by creating a continuous protective border. In some cases, each member is responsible for his own boundary, and in other cases, superior agents are responsible for it.

Distributor

Specific energy is transmitted through a distributor; From the entry point to it and toward the exit point and finally exiting it. This process is associated with a decrease in the concentration of various materials or energy that is used by the subsystems and also with an increase in the concentration of products or wastes produced from the subsystems.

Storage

In the process of producing substance B from substance A, the changes imposed on the rate of process B by changes in the rate of process A can be mitigated by saving a resource (or "buffer stock") of output.

Memory

With the constant assumption of considering other things, the longer the information is stored in the memory, the more difficult it is to call them and the probability of their correctness decreases. But the rate of this loss over time is not regular. The information stored in the memory of a living system undergoes systemic changes over time, which are the result of the processes of selection, an organization with other stored information, and interpretation.

Associator

When a new information input, B, is usually more than once associated with A, which produces a particular output, sooner or later it can produce the same output as A.

Decider

Every adaptive decision consists of 4 steps: 1) Determining the goals that are supposed to be met by the decision. 2) Analysis of information related to the decision. 3) Alternative actions or actions that lead to the goal with high probability. 4) Issuing a signal order to perform actions.

Gilchrist and his colleagues [9] believe that in small groups, the member who receives the most information has a better chance to lead the group.

A decision-making subsystem that receives information from the entire system and from the environment, makes decisions and sends command information that controls a significant part of the process of system units.

If the decision maker deviates upward, downward, or outward, a living system will not exist. Since living systems are inherently interrelated, have similar components, live in comparable close environments, and process energy/materials and information, it is not surprising that they should be comparable and communicative subsystems. have between themselves. All systems do not have all types of possible subsystems. They are different in terms of individuals, types, and mutual levels, as are their subsystems and structures. But all living systems have a complete implementation of key subsystems that perform the necessary things for life or are consciously connected with them and interact effectively with systems that have defects in life.

Stress

The system may experience stress. Information that is stressful is considered a threat to the system. The data entry pattern may be threatening. For example, smelling the smell of a fisherman in the wind changes the acidity of the fluid around the cell.

Lack of Stress

There is a standard range for the rates at which each category of input enters a system. If the input rate is lower than this value, loss stress occurs.

Excess Stress

If the input rate exceeds this value, excess stress has occurred.

Material/Energy Stress

There are different ways for systems to stress. A group of stress includes the following:

a. Lack of material/energy input—famine or lack of fuel input.
b. Excess or excess input of energy/materials.

Information Stress

Information stress is divided into three categories:

a. Lack or lack of information input, which is due to lack of information from the environment or inappropriate functions of external sensory organs or input converter.
b. Introducing a disturbance to the system.
c. Excess information input.

Informational stress may change the rate of information input or their concepts.

GENERAL INTRODUCTION OF THE TEHRAN-NORTH FREEWAY PROJECT

The Tehran–Chalus freeway project was planned with the aim of creating a fast communication route between Tehran and the west of Mazandaran. This freeway is a part of the national north–south freeway, which is the shortest connecting route between the Caspian Sea and the Persian Gulf and will play a major role in the transit of the region. As can be seen in Figure 2, the North Tehran freeway starts from the west of Tehran, and by passing through the winding mountainous area, in a straight distance of about 32 km, it reduces the existing route to 60 km. After reaching Shahristanak, the route continues through Alborz Heights parallel to the existing Karaj–Chalus road to Chalus City. In the end, it is connected to the Chalus–Tenkabon belt with a non-level intersection. The existence of 177 tunnels and 97 bridges along 121 km of the two-lane road indicates a very extensive workload. According to the obtained reports, about 3200 manpower and 970 types of machines in 137 active work fronts are working on this project, which shows the high importance of this national activity [10]. In Table 2, some of the advantages of the construction of this freeway are mentioned.

Table 2. Advantages of constructing the Tehran-North freeway [10].

Shortening the route by 65 km and then reducing the travel time from 4.5 h on normal days to 1.5 h, saving fuel consumption.
Increasing the transit capacity from the capital to the north of the country, followed by reducing air pollution by improving the traffic situation
Creating a fast and safe way of communication for four seasons of the year
Development of the tourism industry, agriculture, and conversion industries
Job creation (during the construction of the freeway and also after its operation)

EXAMINING THE TEHRAN-NORTH FREEWAY PROJECT FROM THE PERSPECTIVE OF LIVING SYSTEMS

The Tehran-North freeway project can be examined from Miller's point of view as a living system. For this purpose, as seen in Figure 3, the hierarchy of living systems is seen from Miller's point of view (on the left) and its equivalent in the freeway project (on the right; Figure 3).

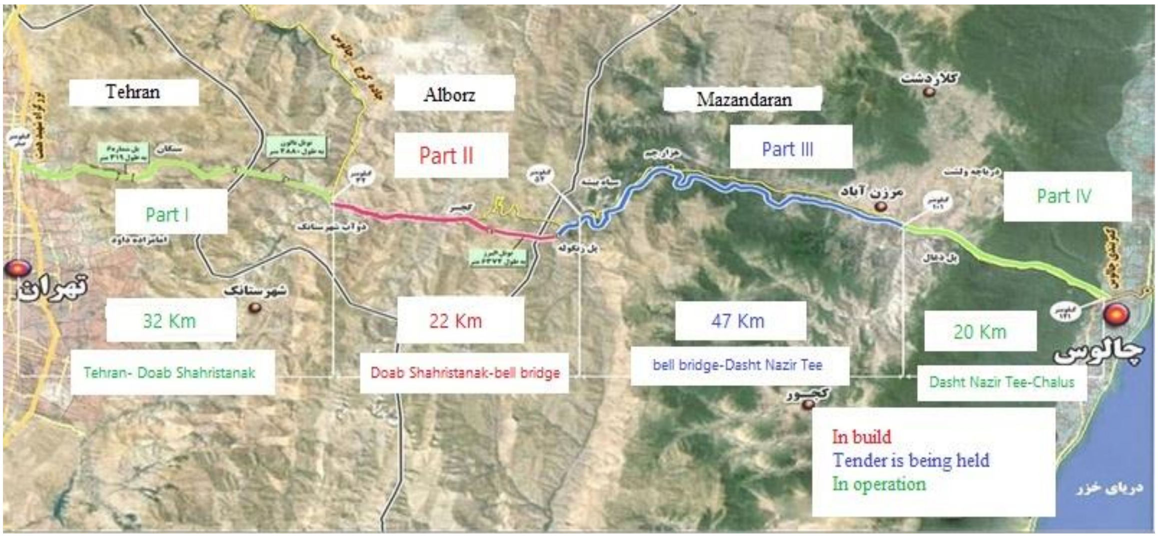

Figure 2. Geographical map of the Tehran-North freeway project [10].

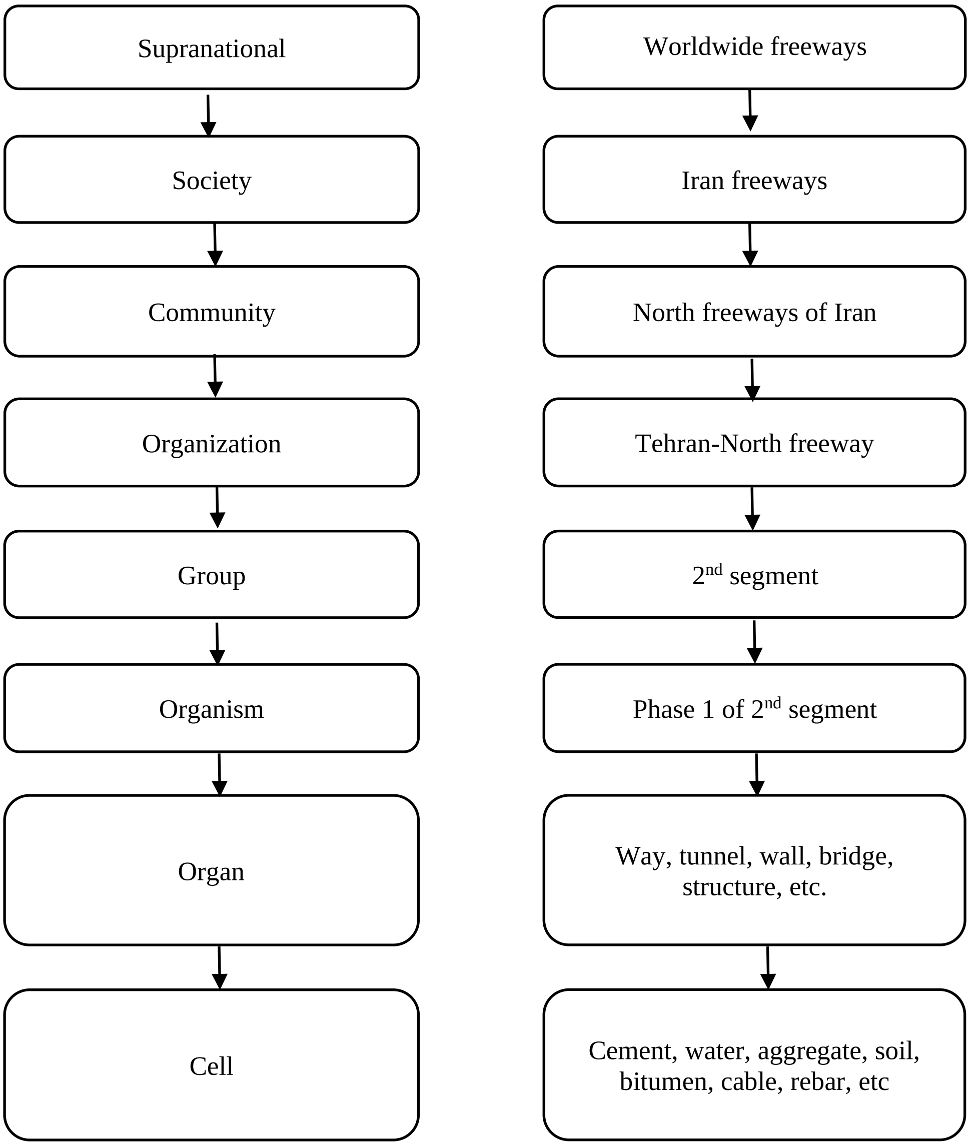

Figure 3. Hierarchy in a living system (left): Miller's view, (right): Azadrah Tehran-North.

Miller has defined 20 subsystems for each of the mentioned departments. In Figure 4, these items can be seen in two categories: materials/energy and information, whose boundaries are defined by the surrounding environment.

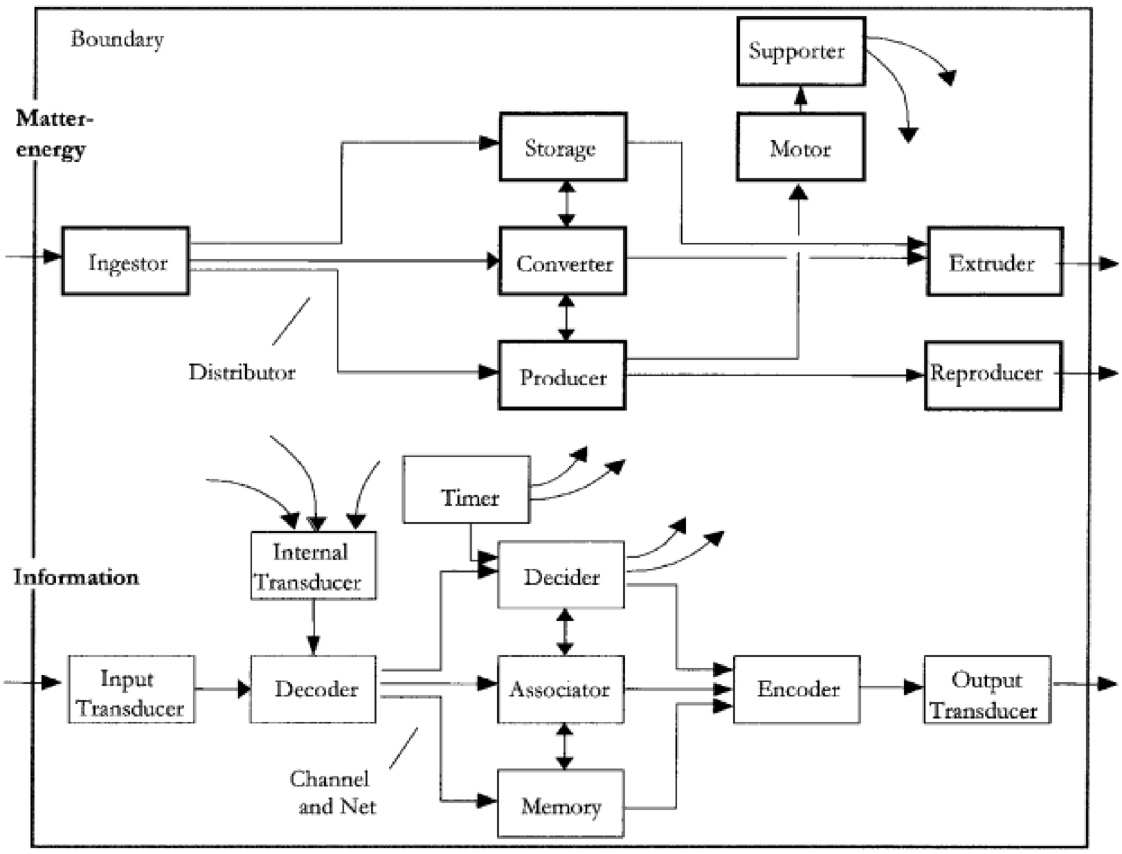

Figure 4. The flow of subsystems in the two parts of matter/energy and information of the living system.

Therefore, it is possible to check the implementation of one phase of one of the parts of the Tehran-North freeway project as a live system.

In a construction project, a series of materials and energy are brought into the workshop on a daily basis. In the Tehran-North freeway project, some of these materials (materials, equipment, machinery) and energy are as follows:

Materials

Necessary materials for making concrete (for pavements, bridges, and tunnels): fine and coarse aggregate, cement, water, and suitable mineral and chemical additives.

Materials for making asphalt (for paving and covering concrete roads): aggregate, bitumen, and suitable additives.

Other materials such as reinforcement (for bridges, the meshing of tunnels, etc.), cables (for bridges), piles (for the foundation of bridges), soil (for embankments), explosives, etc.

Equipment and tools

Mold (for tunnel and bridge), shot device (for the tunnel), safety base (for tunnel and pits), generator, vibrator, pre-tensioning jack, pump, processing covers, bitumen barrel, leveler, shovel, etc. are a small part of the equipment and tools used in this project.

Machinery

Crane, truck, loader, excavator, mini excavator, grader, roller, concrete finisher, asphalt finisher, TBM, road header, etc. are among the machines used in this project.

Energy

A series of energy (production sources) enters the workshop: gasoline, diesel, and electricity.

In addition to material/energy, there is also a series of information going on in the project:

The way of doing activities, schedule of activities, geological information, technical information, contractual information, regulatory information, insurance information, financial information, etc. are some of the information available in the project.

In the Material/Energy Sector

Material/energy is made (prepared) by suppliers who are usually located outside the workshop environment. After the material/energy enters the place, they are stored. Materials/energy before consumption are converted into usable type using converters. Meanwhile, the distribution and movement of materials/energy are the responsibility of transport machines. If the converted product is more than the consumption limit and can be stored, the excess amount is sent to the warehouse. The manufacturer needs a driving engine to make his product, and a supporter is needed to start this driving engine. If the product produced by the factory does not meet the requirements, the product is returned to the factory to be prepared again. In the end, the finisher ends the work by consuming materials/energy in the form of the expected product.

Producer

Oil refinery (oil, gas, diesel, tar, etc.), electricity distribution network, iron smelting plant (iron to a sheet), stone crusher plant (rock and rubble to sand), cement plant (rock to cement clinker)

Storage

Fuel storage tank (gasoline, diesel, oil, etc.), water storage tank, aggregate depot, cement bunker, chemical additive and bubbler warehouse, steel and concrete beam warehouse, reinforcement and parts warehouse, bitumen barrels, soil depot, etc.

Converter

Diesel generator (converting diesel into electricity), cutting and welding workshop (converting sheet into the beam), concrete batching (converting cement, water, and aggregate into concrete), asphalt workshop (converting aggregate and bitumen into asphalt)

Distributor

The fleet of machines includes trucks, dump trucks, trolleys, bogies, etc. (carrying aggregates, reinforcement, bitumen, beams, etc.), loaders (carrying and moving soil), national network (electricity distribution), fuel trucks, equipment that helps in distribution (pump, crane)

The distribution of the product may be directly from the factory or another company may do this as an intermediary.

Motor

Two aspects of the engine can be considered:

a. Types of engines that are required to produce materials/energy.
b. The money (engine driving the project) that has been provided in this project through bonds.

Supporter

The financial support in this project is Mustafafan Foundation, which provides the necessary funds to advance the project through the operating bank. Amal Bank also provides this budget with the money that people have paid to buy bonds.

In the future, domestic and foreign finances will be used to advance the project.

Reproducer

If the product does not have the desired quality (e.g., the bridge harness cables break during pre-tensioning), after referring to the factory, the new product should be replaced. As another example, the minimum durability specifications of poured concrete may not have been met, if there is no repair solution, the previous concrete should be destroyed and concrete pouring should be done again.

Finisher

In the end, the implementation contractor (any specific work including bridge, road, tunnel, etc.) completes the implementation work by placing the converted materials/energy on the project land.

In the Information Section

The decoder should look at the demands of the employer and the characteristics of the environment and the organization as a unit and provide a solution to respond to the demands according to the possible capacities. The input converter receives the project demands (which are presented by the higher authorities) and translates (decodes) them by considering the environmental conditions in the language of the work set (team phase 1 of part 2) so that it is understandable and also be solvable The internal converter takes into account the conditions inside the group (Phase 1 team from region 2) and seeks to define a suitable structure for the group in order to prepare to respond to the goals. It should be noted that these decodings started from the project definition stage and can continue with the progress of the project. The decoder interacts with the decision-maker, linker, and memory. After deciphering the requested activities and matching the group's affairs with them and the environmental conditions, the decision maker should determine the necessary matters according to the specified times. In order to achieve this, he should take the help of time counters (timers) so that the project faces the least delay and on the other hand, the interference of activities and conflicts of the project is minimized. Every decoding that takes place and every activity that is supposed to be done is stored in the memory to refer to them during the project. In the meantime, there is another person who has the role of connecting and is the agent of memory, decision-making, and decoding. After the completion of the information flow model, the information is re-encrypted so that only authorized people have access to it (reasons and changes). This information is stored as project documents and finally, the information model of the implementation of phase 1 of part 2 is exported as an output.

Input Transducer

For example, if the delivery time of part 2 is announced by the employer as 15 months, the input converter should determine the delivery time of phase 1 of part 2 according to the priority and delay of the activity of different phases and their working conditions. This work should be done by a group of experts (this team can consist of controllers, planners, and experienced engineers). In another example, he identified the unknowns of the project (the degree of difficulty of the front of the ground, the presence of holes in the road, the high level of underground water, the phenomenon of freezing and thawing, etc.) and with his analytical reports, he found them The answer is appropriate, comprehensible and comprehensible. This part should be done by companies that benefit from experienced engineers and geologists in their organization and appropriate evaluation devices, and on the other hand, they are well acquainted with the complexities of road construction activities.

Internal Transducer

The structure of the group that is supposed to operate the work should be determined. In this section, the person in charge of the collection (executive supervisor, supervision, etc.) can provide effective help.

Decoder

He simplifies the complexity of the information from the client's demands and the conditions of the work environment in order to prepare the necessary data for executive operations. The best consultant of the employer along with his specialized team are the most suitable people for decoding because, in addition to having the necessary expertise, they also have the most necessary knowledge of the needs of the employer.

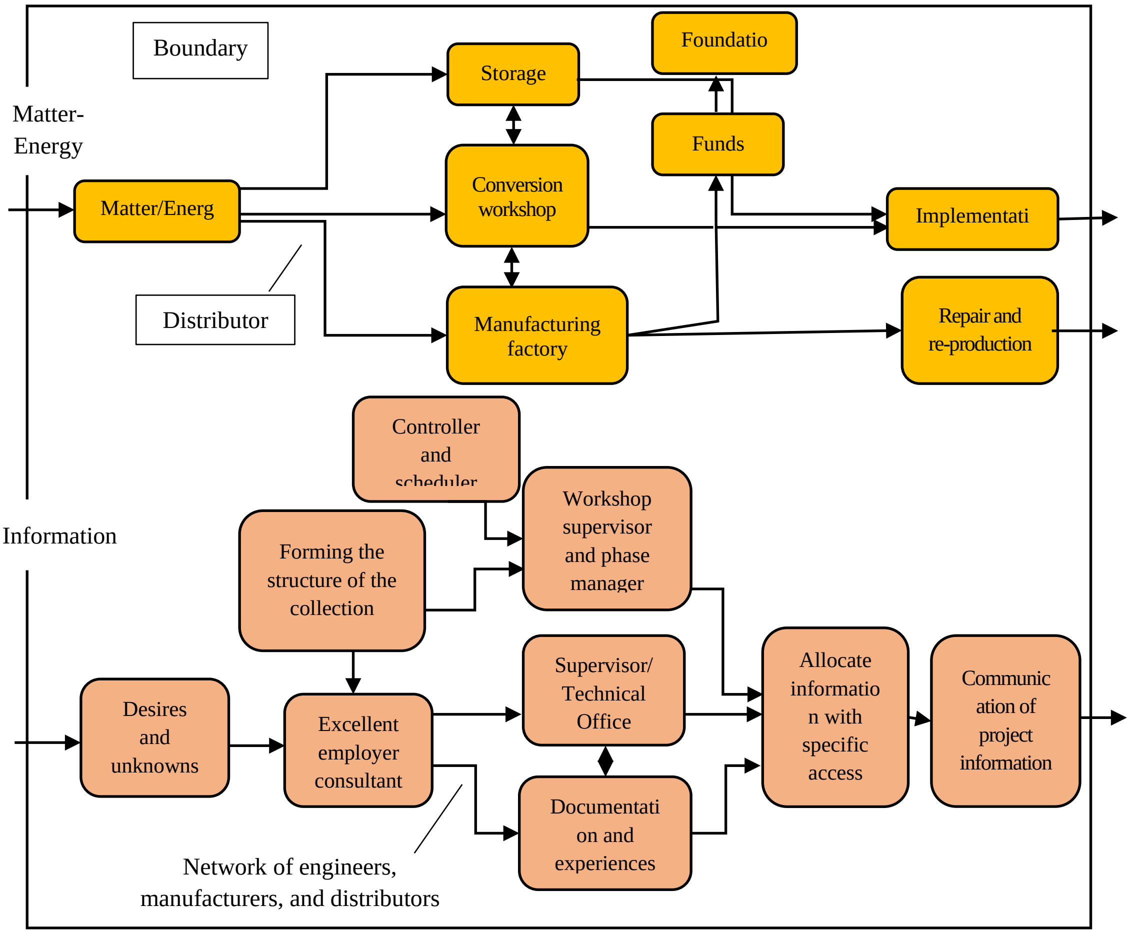

Figure 5. The flow of subsystems in the two parts of matter/energy and information of the Tehran-North Azadrah project from the perspective of the living system.

Therefore, in the three processes of input conversion, internal, and decoding, the main role is played by the employer's top consultant. After explaining the demands in a technical format, he also identifies the overall structure of the collection that should respond to those goals. In the following, the head of the aforementioned department enters into the details of the arrangement of members, processes, allocation of forces to activities, etc., and organizes his collection.

Decider

The decision-maker is not necessarily a single person. Rather, decisions may be the result of a consultation. In the consultation meeting, the presence of the supervisor of the workshop and the engineer responsible for the implementation of phase 1 of part 2 is necessary.

Memory

Documenting the project information makes it possible for the necessary information to be quickly available during the project; In the next projects (and phases), the experiences of the previous projects (and phases) should be used. The process of documenting information is done by the project documenting team. This team does the work of project documentation with the information it obtains and also by using the information of each of the contractors, monitoring, and employer teams. In some projects, there is no documentation team, and the secretariat and the administrative (and financial) departments store this information.

Associator

The project supervisor as well as the people of the technical office can be the intermediary between the decisions taken and the information stored.

Channel & net

The said process is ongoing in a network of consulting engineers, contractors and employers, producers, distributors, and other stakeholders of phase 1 and generally part 2. In the broader view of this network, it is a part of the larger network of the entire Tehran-North freeway project.

Encoder

This process may not exist separately in a building project. But in general, confidential information that only certain people should know about is encrypted. For example, information such as the land use around the project in the future or access to the audit information of the contractor's status, the password of which in the software is provided only to a specific person from the monitoring group.

In Figure 5, the graphic design of the explanation given above is displayed. It should be noted that it is the combination of material/energy flow and information flow that can move the project in the right direction and lead to its success; Materials without information and information without materials do not lead to the achievement of goals.

CONCLUSION

In this work, an attempt was made to look at the Tehran-North freeway project from the perspective of Miller's living systems. The reason for this choice was the dynamics of living systems and the similar basic concept between them and the nature of construction projects. As stated, in the theory presented by Miller for living systems, the flow of matter/energy and information throughout the system was followed and the subsystems and their role in providing the system's goals were investigated.

In the hierarchy defined for living systems, the Tehran-North freeway project is respectively a subset of the freeways of the world, the freeways of Iran, and the freeways of the north of the country, which itself has various phases, each phase It has different parts, each part consists of different structures and each structure is made of different materials. According to the conceptual modeling done, in a specific phase of the Tehran-North freeway project, the flow of matter/energy and information can be modeled as follows:

- The materials/energy required to achieve the project goals are prepared and stored in the appropriate place. Then they can be used in considered converters. The distributor has delivered the materials/energy to the production site so that the necessary products can be prepared using the driving and supporting motor. If the manufactured material/product does not meet the requirements, the material/product is returned to the manufacturer to be prepared again. Finally, the finisher finishes the work by consuming materials/energy in the form of the final product.
- Like the material/energy flow in the project, the information flow must also exist so that the material/energy can be prepared, converted, and finally used in the predefined path. For this purpose, after the project's demands and goals are determined, these items are translated and decoded according to the environmental conditions in the specific language of the work team. The decoder interacts with the decision-maker, linker, and memory. In the following, the decision maker will implement the project activities based on the considered times to minimize future problems. All processes are also recorded in the memory. For the integrity of the connecting presence system, it is necessary to coordinate the general flow of information loaded on the matter/energy transfer process between the existing subsystems. After compiling and completing the information flow, the access levels are determined for each of the beneficiaries through encryption, so that they can be notified to the relevant organization for implementation.

Conflict of Interest

The authors declare no conflict of interest.

Human Participants and/or Animals

This work does not contain any studies with human participants or animals performed by any of the authors.

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