Types of Intelligence in Architectural Design Processes
On the basis of a Phenomenological and Dialectic Model of Design Processes

Haruyuki Fujii, Hideyuki Nakashima¹ and Masaki Suwa²
Tokyo Institute of Technology
¹Future University - Hakodate
²Keio University

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Abstract: This study aims at establishing a constructive methodology of architectural activity. This paper investigates the types of intelligence employed in the activity. The types are derived from a phenomenological and dialectic point of view. The model employs Endo-system view with which a system is observed from the inside of the system. It describes architectural activity from a cognitive point of view of the actor principle involved in the activity.

1. 1. INTRODUCTION

Design science has been trying to give rational understanding and explanation of architectural activity including a process of designing. Logic and computational models are the basic tools to guarantee the rationality of the understanding and explanation. However, since designing contains irrational or intuitive thinking, it is difficult to model a process of architectural activity as logical reasoning or algorithmic computation. This study aims at establishing a constructive methodology of architectural activity making artifacts. This paper proposes a schematic model of a process of architectural activity. The model employs Endo-system view with which a system is observed from a point of view of the first person inside of the system. Therefore, it describes architectural activity from a cognitive point of view of a person who is involved in the process as a principle actor.
The main notions for the construction of the model are the dualism of Noesis and Noema and the causality transcending the levels of aspects to conceive the world. The methodology has both normative aspect and descriptive aspect. The normative aspect concerns how the methodology contributes to the production of a new thing. The descriptive aspect concerns how a process of innovative activity is analysed on the basis of the schematic model of the methodology.

The main part of this paper is composed of four sections. The types of intelligence in architectural activity are investigated through the sections. Section 2 compares architectural activity with scientific inquiry from the external point of view. Section 3 demonstrates that architectural activity is as complex as activity to solve NP-complete problem if architectural activity is formulated as problem solving. Section 4 proposes a model of architectural process from the internal point of view and explains essential notions related to the model. Section 5 shows empirical examples of the types of knowledge employed in architectural activity.

2. ARCHITECTURAL ACTIVITIES – FROM THE THIRD PERSON’S POINT OF VIEW

A model of architectural activity, which is described from an external point of view, is proposed here. Architectural activity is the activity constructing a certain thing that wouldn’t exist without the activity. It contains conception, design, construction, and use of the thing, but architectural activity can be regarded as design in a broad sense. The thing is an aggregation of the organization of its constituents. The main constituents are a building, the environment build by the building and its occupants, the interactions between the environment and the occupants through the building. Each constituent is also a thing so that it is an aggregation of the organization of its constituents.

Architectural activity is purposive in the sense that a thing, or at least a part of it, is made intentionally by human. In this sense, the thing is called an artifact. It is consistent with our intuition that an artifact is generated with the expectation that it brings about desired consequences. Architectural activity is a class of activity to fulfill the desire to build such and such an environment. Such an environment would be created through production of a building and dwelling in it. Once an artifact is created, it is evaluated to anticipate whether the artifact has the potentiality to bring about the phenomenon expected in advance. Whether such an environment is actually created or not is verified through the production and the dwelling. If it is found that such an environment is not created yet and the desire has not been
fulfilled, then architectural activity is continued toward the creation of the environment. More precisely, if there is inconsistency between the expectation and the anticipation, the artifact is modified to resolve the inconsistency. At the same time, the expectation could be updated since something, which could never be known before the artifact interacts with the environment, but plays an important role in architectural activity, emerges in generation as well as evaluation. The cycle involving the generation and evaluation will be continued until the expectation and the observation converge or the resource for the activity is exhausted. Even though the desire is fulfilled, if a new environment brings about another desire, then architecture is continued toward the fulfillment of the new desire.

A model of architectural activity should deal with the characteristics shown above even though it is described from an external point of view. One of the popular ways of modelling architectural activity is to regard the process of architectural activity as the process of problem solving whose definition is following.

*Problem Solving:* Given a set $P$ of all things, find an element of the subset $B$ of $P$ having certain properties.

It is straightforward to regard architectural activity as problem solving. Architectural activity is a process of finding an artifact having the properties that the expectation is fulfilled. We show that the process of finding an artifact to fulfill the expectation is similar to the model of scientific inquiry proposed by Peirce.

### 2.1 Model of Scientific Inquiry

Peirce (1887) modelled a process of scientific inquiry, which is composed of three types of inference stages, i.e., abduction, deduction, and induction. The process model is outlined as follows.

(Sc-0) Every inquiry is triggered by the observation of some surprising phenomena in which inquirer experiences some unexpected things.

(Sc-1) The inquirer ponders the phenomena in all their aspects, invents some hypotheses that shall resolve the surprising phenomena, and selects the hypothesis that seems promising to the inquirer. There is no logical way to invent or select the most plausible hypothesis.

(Sc-2) The hypothesis is tested. The inquirer anticipates the conditional experiential consequences that would be logically or probably derived in accordance with certain inference rules if the selected hypothesis were assumed to be true.
The inquirer estimates the proportion of truth of the hypothesis by verifying how far the anticipated consequences are consistent with the experiential observations and judges whether the hypothesis is sensibly correct, or requires some trivial modification to increase the consistency, or must be rejected.

Stage Sc-1, Sc-2, and Sc-3 are repeated until the inquirer makes the hypothesis plausible enough to explain the surprising phenomena.

The inferences performed in stage Sc-1, Sc-2, and Sc-3 in scientific inquiry are abduction or retrospection, deduction, and induction, respectively.

Abduction, performed in stage Sc-1, is the conjecture in which a new hypothesis or theory is invented or discovered. Abduction enables the inquirer to reason about the things that are not being or cannot be perceived directly or experientially and to draw the conclusions that are not already included in the preconditions. However, it doesn’t secure the truth of the consequences.

Deduction, performed in stage Sc-2, is logical analysis to explicate the hypothesis. It derives the necessary consequences implicated in the hypothesis. The consequence cannot be false if deduction is processed rightly. In other words, only true conclusion is derived from true preconditions and true hypothesis. Modus ponens exemplifies the formula for deductive reasoning.

Induction, performed in stage Sc-3, is classification of the instances of experience. General ideas, which subordinate empirical observations, are constructed on the basis of the observations. Existence of the unknown or inconceivable things that belong to the same class that the empirical observations belong to is concluded. The truth of the consequence is not secured, either.

2.2 Architectural Activities as Scientific Inquiry

Architectural activity is modeled focusing on there forms of inferences in scientific inquiry. It will be confirmed that the manner of thinking in architectural activity is quite similar to that in scientific inquiry.

Every architectural activity is motivated by the consciousness of one’s intention to build a certain environment. An exploration into the nature of an artifact that brings about the environment begins.

The actor of architectural activity imagines, on the basis of the past and present experiences, how the environment could change if certain artifacts are made. The actor invents some hypotheses that shall fulfils the intention, and selects the hypothesis that seems promising to the actor. An
artifact that is consistent with the hypothesis is designed. There is no logical
way to invent or select the most plausible hypothesis and to design the
consistent artifact.

(Ar-2) The actor anticipates the conditional experiential consequences
that would be logically or probably derived in accordance with certain
inference rules if the selected hypothesis were true and the artifact were
made.

(Ar-3) The actor actually makes the artifact and verifies how far the
anticipated consequences are consistent with the experiential observations as
estimating the proportion of truth of the hypothesis and judges whether the
artifact and the hypothesis are sensibly correct, or require some inessential
modification to fulfil the intention, or must be rejected.

(Ar-R) Stage Ar-1, Ar-2, and Ar-3 are repeated until the actor makes the
artifact that builds the intended environment.

A comparison of scientific inquiry and architectural activity shows that
they are similar to each other if we focus on the forms of inferences
employed in scientific inquiry and architectural activity. It is important to
note that either abduction or induction doesn’t have logical inference rules
that guarantee the truth of the consequences in spite that deduction does.
Therefore, the success of architectural activity as well as scientific inquiry
depends not only on the procedural schema like the rules of deductive
reasoning but also on the heuristic capacities to be employed to select the
most plausible hypothesis, to classify the empirical observations, and to
imagine a course of action towards the goal.

3. ARCHITECTURAL ACTIVITIES AS NP-COMPLETE PROBLEM SOLVING

We demonstrate that if a process of architectural activity is formulated as
a process of problem solving then the computation to find a solution artifact
is an NP-complete problem. Where, “NP” stands for “non-deterministic
polynomial time”. This means that a lot of computation is required to find a
solution artifact if the solution is searched in a deterministic algorithm such
as the depth first search. However, it is known theoretically that a certain
non-deterministic computation can find a solution in shorter time. The
intelligence and intuition concerning architectural activity may help the actor
to reduce the time to find a solution artifact.

Suppose that we have a set of constituents Σ_a to form the structure of
artifacts and a set of constituents Σ_s to form the situations build by the
artifacts. Every artifact is organized as a subset of Σ_a. Every situation is
organized as a subset of $\Sigma_s$. There are two types of binary relations on the union of $\Sigma_a$ and $\Sigma_s$. The relations show the dependencies among the constituents of an artifact and a situation such as the physical laws. They are the followings: if a certain constituent appears to organize an artifact or a situation then another certain constituent must also appear, and if a certain constituent appears to organize an artifact or a situation then another certain constituent must not appear. Architectural activity is defined as problem solving as follows with these set.

**Architectural Activity:** Given a set of all artifacts (the power set of $\Sigma_a$) and an element of a set of all situations (the power set of $\Sigma_s$), find an element of the subset $B$ of the power set of $\Sigma_a$ that entails the element of the power set of $\Sigma_s$.

Let $U$ be a set of variables. Each variable in $U$ expresses whether a certain constituent in $\Sigma_a \cup \Sigma_s$ that corresponds to the variable appears or not. Suppose that $u_i \in U$ corresponds to $d_i \in \Sigma_a \cup \Sigma_s$. The value of $u_i$ is 1 or 0. The value is 1 if and only if $d_i$ appears. The value is 0 if and only if $d_i$ does not appear. Then, every subset of $\Sigma_a \cup \Sigma_s$, which shows every combination of a certain artifact and a certain situation, is expressed as a particular combination of the values of all variables in $U$. The dependencies between a constituent and another constituent in $\Sigma_a \cup \Sigma_s$ is expressed as the dependencies between the value of the variable corresponding to the former constituent and the value of the variable corresponding the latter constituent.

Architectural activity is formulated as a process of determining the values of all variables in $U$. The values should have the properties that the values of some variables are pre-determined as a part of the goal of architectural activity and that the values of some values are determined depending on the values of the variables on the basis of the dependencies. This formulation of architectural activity is equivalent to Satisfiability Problem (or, SAT). Cook’s theorem says that SAT is an NP-complete problem. Therefore, architectural activity is an NP-complete problem if it is regarded as a problem solving and formulated as shown above. A lot of computation is required to find a solution artifact if the solution is searched in a deterministic algorithm. The resources, time and space, for the computation explosively increase if the size of a problem increases. On the other hand, it is known theoretically that a certain non-deterministic computation can find a solution in shorter time. A Non-Deterministic Turing Machine may find a solution for architectural activity in polynomial time.

The intelligence and intuition concerning architectural activity may help the actor to reduce the time and space to find a solution artifact. It should be emphasized that not only logical and rational thinking but also intuitive and
heuristic thinking, which may look illogical or irrational if it is observed from the external point of view, may lead architectural activity towards the success.

4. **ARCHITECTURAL ACTIVITIES – FROM THE FIRST PERSON’S POINT OF VIEW**

A model of a dialectic process of architectural activity is proposed here. The model, which is the current product of the ongoing project by the authors, is being constructed to understand and explain the natures of architectural activity from the first person’s point of view and to pass the first person’s understandings down.

A model of architectural activity described from the external point of view is revised here to deal with the internal point of view of a designer who is involved in the process of architecture. We found that non-logical thinking is required for architectural activity by modelling the activity as scientific inquiry. We found, from a point of view of computation, that architectural activity is an NP-complete problem, which requires large resources by modelling architectural activity as problem solving. These models are constructed from the external point of view. We are trying to approach how human performs architectural activity by constructing a model of architectural activity from the internal point of view of the actor. The crucial characteristics of the model are that it is composed of multi-layered representation of the things involved in architectural activity and that the process is a dialectic cycle composed of generation stage, test stage, and evaluation stage.

4.1 **Noesis and Noema**

Inspired by phenomenology, we introduce the notions of Noesis and Noema to express a model of architectural activity from an internal point of view of the actor involved in the activity. The notion of Noesis refers to the agency of intentionality with which one affects the external world and the actor’s understanding of the world. Noesis gives the substances into the representation. The notion of Noema refers to the representation acquired through the intentional Noesis activity of the agent. Husserl employed Noesis and Noema for the phenomenological analysis and description of intentionality. Kimira expands the scope of the notions so as to deal with the bodily movement performed intentionality, i.e., action.

We are following the expanded version of the definitions and introduce the notions of I-Noesis and E-Noesis. I-Noesis is the Noesis defined by
Husserl. It is the agency of intentionality towards one’s consciousness. E-Noesis is the Noesis expanded by Kimura. It is the agency of intentionality towards the consciousness as well as towards one’s interaction with the world via the bodily movement. Architectural activity, as shown above, involves a process of contemplation and a process of externalizing. I-Noesis is involved in the contemplation process. E-Noesis is involved in the externalizing process.

We also introduce two types of Noema, i.e., the current Noema and the future Noema. The current Noema represents, through I-Noesis as well as E-Noesis, one’s current projection of the world and the future Noema represents, through I-Noesis, the current picture of the world to be faced in the next instance. I-Noesis, E-Noesis, the current Noema, and the future Noema work as the motives in a process of architectural activity. The current and future Noema differ to each other because there are unexpected interactions at the Noesis level, and emergent, and therefore unexpected, property appears in the current Noema. The current Noema and the future Noema let the actor intend to do certain things to get the projection that is expected to be gotten. Through E-Noesis, the content of how to realize the picture is practiced. A state of affairs of the physical world – the world composed of the referents of Noema - changes as the result of the practice. The consequence of the practice and the future Noema are compared to construct the new current Noema and the new future Noema. We define the vertical relationship between Noesis and Noema. Noema is the upper and Noesis is the lower when there holds the relation that an element of Noema refers to the counterpart entity on Noesis.

It is assumed that the Noema itself is composed of a diverse of levels corresponding to the aspect employed in architectural activity and that the world is represented from a diverse of aspects. The aspects have the following characteristics. When we make an artifact, we see it from several aspects. Although there is only one artifact is being designed, there are several representations in different conceptual levels are involved. Some of the aspects are organized as having hierarchical relations with each other with respect to the level of the abstractness, the scale, the granularity, and the collectiveness of the representation of the things. The representation of Noesis is also a habitant of Noema. Noesis is also represented from a diverse of aspects as Noema. For the convenience of the discussions, we define that a Noema level is upper than the corresponding Noesis level. The other aspects don’t have hierarchical relations with any aspect. It is often the case that an element or a collection of elements seen from one aspect doesn’t have any counterpart in other aspects. In other words, some aspects cannot be reduced into other aspects. We assume that Noema has multiple layers of
the representations including the representation of the Noesis level of things. Each layer corresponds to each aspect employed to describe the design world.

The expectation and the anticipation in architectural activity are represented in the Noema levels. The difference between the expectation and the anticipation let a designer to make decisions about what should be generated, how it could be generated, what should be tested, how the test should be done, how the differences and gaps between the expectation and the anticipation are evaluated, and how the differences and gaps are resolved.

![Diagram showing types of Noesis and Noema and their relations.](image)

*Figure 1. Types of Noesis and Noema and their Relations*

### 4.2 Model of Architectural Processes

Through architectural activity, we make an artifact to make an affective ensemble of our lifestyle and the environment surrounding us. The artifact has the concrete form made of concrete matters. Our understandings of the relations between the lifestyle and the environment are embodied in an artifact. The artifact works as a medium to facilitate the ensemble. The ensemble manifests itself upon the interaction of us with the environment through the artifact. A successful artifact changes our lifestyle or the
environment toward better directions with keeping the ensemble. Through the experience of the ensemble and the changes, we will become aware of new relations among the lifestyle, the environment, and the artifact. Some of the relations would not be noticed without the experience. When the fluctuations in the changes are so great that the ensemble can hardly maintain a consistent balance, a new effective ensemble, which is expected to resolve the inconsistency, might be desired and a new artifact would be made to make such an ensemble. Our revised understanding of the relations of the lifestyle and the environment would be embodied. Through the experience of using an artifact, we become to discover or invent new relations among the artifact, the lifestyle, and the environment. We would have desire to make a new ensemble inspired by the new relations.

The authors model an architectural process as a dialectic spiral cycles of generation, evaluation, and focusing.

*Generation* is a process of embodying and externalizing the internal ideas. The private thoughts are materialized as a certain structure of entities and exposed to the environment so that the public form of ideas interacts with the environment. The notion of generation contains a process of carrying a plan devised after logical deliberation to fulfil the purpose as well as a process of trying to employ or make something intuitively for the present in the hope of promoting the purpose. Synthesizing something is one of the subclasses of generation. Generation involves the process of changing the states of affairs in the world. Action with bodily movement is required, by definition, since the essence of generation is to change a world.

As soon as an actual entity is given to the internal ideas, the entity interacts with other entities in the environment. The interaction results in the change of the states of affairs in the world, which is composed of the entities, and brings about a certain phenomenon. It should be emphasized that the interaction occurs in the lower level of the current Noema and the future Noema in the sense that it affects on the entities as well as the representations. We call this process as *interaction*. The frequency and impact of the interaction as well as the time span and the effective range of the phenomenon depend on the relations among the entities.

*Evaluation* is a process of observing the progress and consequence of the interaction and of comparing the observation and the expected picture drawn prior to the preceding generation. The observation and comparison are mainly made from a point of view used also in the generation. Sometimes, emergent and unexpected things are observed serendipitously. It also depends on the point of view and the flexibility of the observation if the emergence is captured or not.

*Focusing* is a process of defining the right or promising orientation of generation and evaluation. A particular concern is selected and featured in
the current design. A course of action for the succeeding generation and evaluation is directed with respect to the concern. More precisely, the current milestone, the aspect concerning how to evaluate whether the milestone is reached or not, and the strategy to generate an artifact that gets good result in the coming evaluation. Focusing is classified into two types, i.e., rational, logical for example, focusing related to the current or prior deliberation and intuitive and heuristic focusing sometimes involving interpretation change.

Each of generation, evaluation, and focusing has the recursive structure that is composed of cycles of smaller generation, interaction, evaluation, and focusing. Where, a process is smaller in the sense that the granularity to represent it is more microscopic or the time span of the process is shorter.

The process described above is modeled as follows. Figure 2 depicts the spiral cycle in the model.

(C-1) Generation is performed. The action to approach the goal, which is currently pictured as future Noema $NF(t)$, is performed. This process corresponds to the 1st moment introduced by Kimura. The actor anticipates the experiential consequences that would be deductively derived if the selected hypothesis on the relations between the action and an environment were true and the action were performed.

(C-1.5) The action planned on the previous stage is actually performed. The actor makes an artifact and experiences the interaction between the action $A(t+1)$ and the environment $E(t+1)$. The actor also experiences the phenomena brought about through the interaction. Some of the phenomena are anticipated, but the others are brought about by chance for the actors. In our model, it is assumed that it is impossible for the actor to anticipate all of the phenomena. A certain hypothesis and a certain aspect are required to anticipate a certain phenomena. Before the hypothesis is constructed and the aspect is employed, the phenomena are not noticed.

(C-2) Evaluation is performed. The actor observes and interprets the consequence of the interaction. Focused portions of the interaction and the phenomena brought about through the interaction are appreciated and construct the representation of the result of the appreciation. The representation is the current Noema $NC(t+1)$. This process corresponds to the 2nd moment introduced by Kimura. The actor verifies how far the anticipated consequences are consistent with the experiential observations. The actor may estimate the proportion of truth of the hypothesis and judges whether the artifact and the hypothesis are successfully made, or require some inessential modification to fulfill the intention, or must be rejected. The actor constructs hypothetical relations between the action and the consequences on the basis of the past and present experiences of the interaction.
(C-3) Focusing is performed. If the actor is not satisfied with the consequence of the evaluation, a new goal is pictured. The picture is the future Noema $NF(t+1)$. This process corresponds to the 3rd moment introduced by Kimura. The actor of architectural activity imagines, on the basis of the hypothetical relations between an action and the consequence, how the environment could change if certain artifacts are made. The actor invents some hypotheses that shall fulfils the intention, and selects the hypothesis that seems promising to the actor. An artifact that is consistent with the hypothesis is designed.

The actor repeats the cycle of Stage C-1, C-2, and C-3 until the actor makes the artifact that builds the intended environment.

![Figure 2. Model of Architectural Process (FNS-Diagram)](image)

### 4.3 Polysemic Dualities

Since one of the objectives of architectural activity is to produce an artifact for the purpose of providing certain interactions among the artifact, its user, and the environment where the artifact is used, by definition, there must be a goal in architectural activity. Defining what is ought to be provided by a prospective artifact is a prerequisite for formulating E-Noesis about how the artifact is constructed so as to embody the expectation.

The essence of architectural activity, in our model, is to purposively construct a system that had never existed before the activity. The notion of system refers to the thing that consists of the composition of concrete matters, the organization of forms, the order of principles, and the relations among them. These constituents of the system let us observe an artifact as its structure, its characteristics, and its mechanism coupling the structure and
the characteristics. The structure is characterized as a collection of elements and a formation of the elements. The characteristics of the system emerge out of the interaction of the structure with its environment. The impact of the interaction on the environment as well as on the system is a constituent of the characteristics. Some of the characteristics are expected to appear as a consequence of producing the system. Such expected characteristics are mainly described in terms of the functional and behavioral features. The mechanism colligates the structure and the characteristics. When we are making an artifact, we are producing the structure of the artifact, the characteristics brought about by the artifact, and the mechanism coupling them simultaneously.

Architectural activity makes an individual system as well as a general system. In parallel with making an instance system, we are also synthesizing the form, from which artifacts in the same class is instantiated, and formulating the principles, which show some certain directions for architectural activity. The system is individual in the sense that it is constructed for the purpose of fulfilling particular expectations for the system in a certain situation. The system is general in the sense that applying the system to different situations may produce similar individuals. The individuality and the generality are mutually necessary even if it varies in accordance with interests in architectural activity on which the emphasis falls. A general system is constructed through the abstraction of interested features from an individual system. The general system is transmitted from the original individual system to other individual systems by producing them. An individual system is constructed by embodying the form made up with interested features of a general system in the formation of concrete matters.

The mechanism is looked at in two levels at the same time. In the concrete level, a certain individual mechanism, which is composed of an individual structure, the phenomena brought about through the interaction between the structure and the environment. In the abstract level, the relations classifying the instance phenomena are seen. The abstract level is excerpted from the concrete level and transferred for another instance of the mechanism to be reproduced. The details of the mechanism are conceived in terms of the relations between the structural features and the variables describing the characteristics. The relations are what bring the structural features to bear the functional or behavioral characteristics suitable for the purpose of architectural activity. The causality of the relations can be hypothesized intuitively and updated later. Once the probability is conceded that a certain structure will provide certain characteristics, the relation between the structure and the characteristics could become to be used intentionally to provide similar characteristics.
4.4 Inter-Level Causality

The types of intelligence employed in architectural activity are derived from the model of architectural activity. They contain the type of the formal and scientific knowledge employed in the generation and the evaluation, the type of the procedural knowledge for the planning of a course of events in the generation, the type of intuitive intelligence used to determine what should be focused in design process on-the-fly, the type of knowledge to formulate what should be planned on the basis of the focus, and so on. Since the tacit types of knowledge is hardly formalized, such types are indirectly explained in terms of its significance, roles, emergence, usage and so on.

The crucial issue left here is to explain how a particular E-Noesis on the current Noema towards the future Noema is intended among a collection of alternatives and how a particular I-Noesis to acquire significant information through the interaction is intended. A process of making an artifact is not an arbitrarily or randomly performed activity. It is not the case that every action in the process is performed arbitrarily or randomly. Some actions that fit the intended purpose of making an artifact are performed. The relations among the elements of an ensemble and the ensemble that have the nature of a law are consciously applied to the making of an artifact with the intention of making sure that the artifact facilitate the expected ensemble. It is essential for the success of artifact making that we are aware of the existence of the nature of a law and that we make an artifact with the consciousness of applying it, but it is not necessary to know what exactly the content of the nature of a law is (Taketani, 1963). It is not necessary that the nature of a law is objective and public in the sense that it is verified in a so-called scientific manner, either. Even though it is subjective and private, it is useful. The nature of a law related to the making of an artifact is classified into two subclasses. One is the nature of a law among the things that composes the artifact and its environment. A law in this class is basically expressed as an equilibrium governing the things. Thermal and is a typical form of the relation. The other is the nature of a law among the events that composes our interaction with the environment including the artifact. The basic form of the expression of a law in this class a relation between two events. One event is expressed as the cause of the other event or as the effect of the other event. At least one of the two events is our action. When an action is the cause of the other event, the event is the result or consequence of the action.

We introduce, here, the notion of inter-level causality, or vertical causality, to deal with the nature of a law that is not necessarily objective, logical, or universal in the scientific sense. The notion refers to the causality among the constituents in the different conceptual level. It should be subjective, or private, in the sense that it represents personal understanding.
of the world acquired through the experience. The inter-level causality may also be objective, or public. However, the objectivity in the inter-level causality is limited since the aspects cannot be reduced into each other. We emphasize that the objective type of causality navigates the designer towards rational direction and that the subjective type of causality navigates the designer towards a creative direction. When we design an artifact, we go back and forth among the conceptual levels on the fly with the vertical causality. The balance between the two types of causality makes a design successful. One typical and significant form of inter-level causality is the relation between the emergent behavior of a system and the movement of the constituents of the system. Another significant form is the relation between the variables controlled directly and the consequence of the control. The understanding of the relation between the representation of Noema level and that of Noesis level is one form of the latter inter-level causalities. The contents in the Noema level representation is embodied in the Noesis level through some inter-level causal relations.

5. TYPES OF KNOWLEDGE FOR CONSTRUCTION OF A VERNACULAR HOUSE

The types of inter-level causality are classified on the basis of the empirical data concerning a construction process of a vernacular house. The data are extracted from a literal record of the folk tradition to hand down the knowledge about how they construct the house and the culture of the region the house is located (Kayano, 1976). The original text is written in Ainu and is translated into Japanese by the author of the book himself.

The Japanese text is composed of 522 sentences. The sentences are simple sentences, compound sentences, and complex sentences.

The simple sentences are classified into two types, i.e., <STATE> type and <EVENT> type including <ACTION> type. Most simple sentences are <ACTION> type. The sentences of <ACTION> type describes the actions performed in the construction of a particular house, which is constructed to record the construction process, and the actions performed in the construction of a house of the same class in general.

The compound sentences show courses of the actions in the construction process. A sentence of this type defines an assembly operation of a certain constituent of the house. The structure of the house is implied indirectly in the compound sentence.

The forms of complex sentences are classified as follows.

(Cx1) Since <EVENT>, <ACTION>.
These types of sentences describe the causality between the vital actions for the construction and the things related to the actions.

A sentence of type Cx1 describes the cause or the reason of the action focused in the sentence.

A sentence of type Cx2 or Cx3 describes what would happen in general if a certain action were performed or what did happen when a certain action was performed in the construction of the particular house. The former tells us general causality and the latter informs us of the significant experience in the construction process. It is interesting that some causality mentions gods in Ainu religion and that no causality mentions so-called natural laws found by modern science.

A sentence of type Cx4 or Cx5 implies the teleological reason of the action focused in the sentence. We can read that the causality embedded in the sentence in the form of \( \text{ACTION} \) then \( \text{EVENT} \) or \( \text{ACTION} \) then \( \text{STATE} \) is consciously applied and the content of \( \text{ACTION} \) is performed.

6. CONCLUSIONS

Architectural activity is analogous to scientific inquiry if we focus on the inferences employed in them. Architectural activity as problem solving is NP-complete. A model of architectural process expressing its dialectic and phenomenological nature is proposed.

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