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Finer Investigation into Role

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***Abstract*—This paper discusses three issues about role: (1) continuity of role playing in the case of role change, (2) role as specification and (3) vacant role. As to (1) we introduce decomposition of a role into two subroles: post subrole and constituent subrole. The latter is crucial for coping with the issue of continuity. The idea of role as a specification is proposed after detailed discussion about what a role should be. Finally, the third issue is addressed by introducing a new idea of virtual player to harmonize all the new ideas proposed in this paper. A preliminary result of formalization of the new theory is presented.**

I. Introduction

ROLE instantiation is problematic, in particular, the notion of instance of "vacant role" is unsettled. Intuitively, a vacant role is a role which is not played by any entity. What is vacancy of a role how and where does its instance exist? A relational model of roles has a difficulty to answer this question, since when a participant disappears, then the relation also disappears at the same time. We have to confess that we do not know what vacant role is very well in the first place.

In an organization, people are promoted to a higher position and then change their roles. Suppose we let John play a role, say, Deputy director, then John would lose his participation in the organization at the very time of his promotion up to Director, and hence John's participation in the organization loses continuity.

Social roles like President of a country which is clearly defined in its constitution need descriptions [11]. Then, do all kinds of roles need descriptions? Some say no, but what kinds of roles need a description is unclear.

We discuss three issues of role as fundamental concepts useful for better understanding about role.

(1) As to the first one we propose decomposition of a role into two subroles: *post subrole* and *constituent subrole* to address the issue of role change and that of the instance management of roles.
(2) The second one is about what a role is. We propose a new view of roles, that is, view of a role as a specification.
(3) Our current understanding about vacant role [15] is a bit too weak to explain the reality of a vacant role in the real world. We introduce *virtual role-holder* and *virtual player* to address this issue. It contributes to better understanding about vacant role.

This paper is organized as follows. The next section overviews our model of roles discussed in [5,14,15] to provide readers with background of the discussion of a new model of roles. Then, these three issues are discussed in Sections III, IV and V, respectively. Related work is presented in Section VI followed by concluding remarks.

II. Overview of our role theory

A. Basic model of a role

The fundamental scheme of our roles at the instance level is the following (see the lower diagram in Fig. 1):

"*In Osaka high school, John plays teacher role-1 and thereby becomes teacher-1*"

This can be generalized to the class level (see the upper diagram in Fig. 1):

*"In schools, there are **persons** who play **teacher roles** and thereby become **teachers**."*

By **play**, we mean "acts as", that is, it contingently acts as according to the role (role concept). By "**teacher**", we mean a class of dependent entities which roughly correspond to persons who are playing teacher roles and which are often called *qua individuals* [11]. Here, we introduce a couple of important concepts to enable finer distinctions among role-related concepts: ***role concept***, ***context***, ***role-holder***, ***potential player*** and ***role-playing thing***. In the above example, these terms are used as "*In a context, there are **players who** play **role concepts** and thereby become **role-holders***".

By **context**, we mean a class of things that should be considered as a whole. Unitary entities and relations can be a context. **Role concept** is defined as a concept which is played by some other entity within a context. So, it essentially depends on the context. By **potential player**, we mean a class of entities which are able to play an instance of a role concept. In many cases, basic concepts (natural types) can be used to denote classes of **potential players**. When an instance of potential player is playing an instance of a role concept, we call the instance a

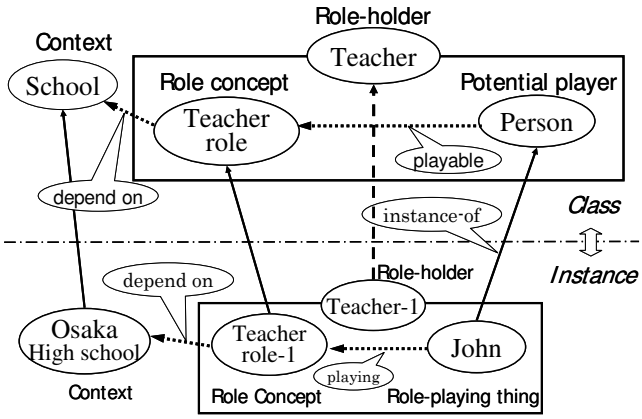

Fig. 1. Fundamental scheme of a role concept and a role-holder.

role-playing thing. In this example, we say a person can play an instance of a teacher role. In particular, John is actually playing a specific teacher role *teacher role-1*. By doing so, he is associated with the instance *teacher-1*, an individual teacher **role-holder.** A role-holder class is a super class of dependent entities like teacher-1. As such, it is neither a specialization of a potential player class (e.g., person) nor that of a role concept class (e.g., teacher role), but an abstraction of a composition of a role-playing thing and an instance of role concept, as is shown in Fig. 1, which is the heart of our Role model.

The link from Teacher-1 to Teacher is a broken arrow rather than a solid one like *instance-of* link to show the relation is not completely same as *instance-of* relation in Fig. 1. Neither our model nor Hozo tool allows people to directly generate an instance of role-holder classes because the individual role-holder as a dependent entity to be instantiated first requires an instance of a potential player class and that of a role concept class. Then, when the playing link is asserted, it virtually acquires the properties of the potential player and the role concept. This is why role-holders are dependent entities.

All the concepts introduced here are core of our role model and contain rich implications which are elaborated in [15]. The above shows that we divide the conventional notion of "Role" into two kinds: role concept and role-holder in our model. Therefore, our model of roles does not have the concept of "Role" explicitly. In particular, it is understood conventionally that a role existing at the instance level must be something being played by something, since people understand the role instantiation and the action of playing the role as happening at the same time. In contrast, in our model a role concept can exist at the instance level without being played, since it depends only on its context and not on its player. While the concept of role is the target of the ontological research on roles, at the same time, this term has been the source of confusion, since it hides the difference between role concept and role holder.

B. Hozo representation of our role model

Fig. 2 shows the correspondence between the role model and its Hozo representation. Because Hozo is based on frames, the representation is rather straightforward. Additionally, we discussed theoretical solid foundation and formal definitions of our role theory in previous work [15]. In the paper, we discussed the solid foundation of role model and presented its semantics using OWL to clarify its formal definitions. The details of role representation model using OWL and SWRL are discussed in [7]. Hozo also can export ontologies in OWL.

Let us explain Hozo's representation conventions by using the example shown in Fig. 2. In Hozo each concept defined as a class is represented in a rectangle like *School* and *Person*. Each class is defined by specifying its parts (denoted by "p/o") and/or attributes (denoted by "a/o") as slots. *School* is here defined as an entity composed of teachers and students where *teacher role* and *student role* are role concepts played by individuals specified by the rectangle at the far right, instances of *Person* in this case. As shown in Fig.2, the key idea of class definition in Hozo is that all concepts, which can theoretically be parts of something, are defined independently of the possible wholes which they can be part of, and each class as a whole is defined by specifying the roles whose parts play. In other words, all the class definitions in Hozo are reciprocal, in the sense that a whole (School) is defined in terms of its parts (Person) playing their own roles, and at the same time, the roles (teacher role) played by the parts (Person) are defined there under the context of the whole (School).

Is-a (super-sub) relations between basic concepts are represented by *is-a links* as shown Fig.3. In this example, *University* is defined as a sub concept of *School*. Sub concepts inherit all role concepts from their super concepts, and sometimes they specialize inherited role concepts to define the role concepts in their context. Fig.3 shows two role concepts *(full) professor role* and *associate professor role* which are defined in the context of *University*. They are sub concepts of *teacher role* in *School*. The relationships between these role concepts are represented by describing the super concepts on the right

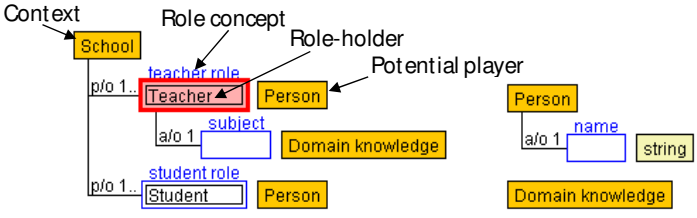

Fig. 2. Hozo's representation our role model.

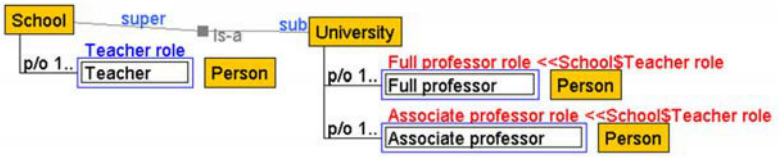

Fig. 3. Representaion of an *i-a* hierarchy of role concepts.

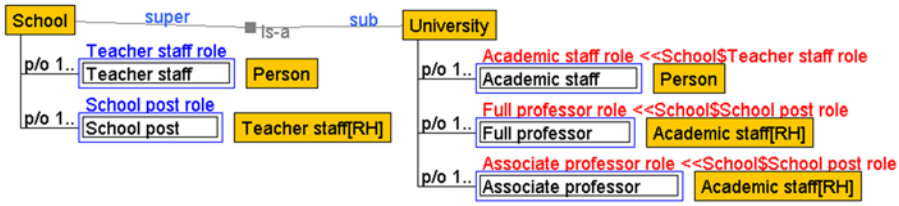

Fig. 4. Distinguishing between academic staff role and professor/associate professor role.

of role concepts with double angles "<<" as shown in Fig. 3. It means the hierarchy of role concepts is analogue to the hierarchy of basic concepts because all role concepts are defined within the basic concepts as their contexts.

III. Introduction of Post Role and Constituent Role [7]

A. Motivating example

Let us consider the behavior of an instance of roles in the case of promotion in a university. We take an *associate professor role* and a *full professor role* as examples which are defined in the context of a university. In this example, an associate professor John in Osaka University is represented as follows:

John plays an instance of the associate professor role and thereby becomes an associate professor (role-holder).

Now, we assume a case where John is promoted from associate professor to full professor. It means that John stops to play the instance of the *associate professor role*, then plays the instance of the *full professor role*. In this example, when John plays the instance of associate professor role or full professor role, he also plays *teacher role* in the university at the same time. Because <both full professor role and associate professor role *is-a* teacher role> as shown Fig.3, the semantics of *is-a* relation tells us that John stops to play the instance of teacher role at the very moment when he changes the role to play. This is because one has to stop to play the current role when he/she starts to play the new role. In other words, the continuity of playing the *teacher role* is lost. Obviously, this example model does not capture the behavior of the instances in the real world accurately. In the real world, John must have been the same teacher both when he is the associate professor and the full professor.

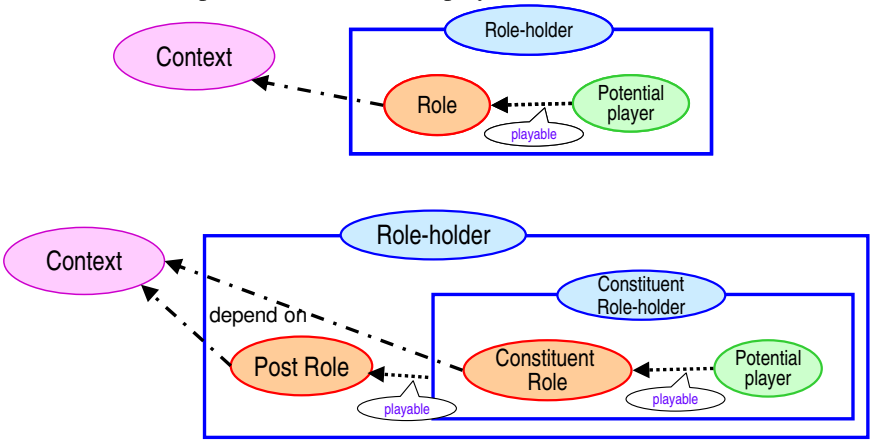

Fig. 5 Extension of the framework.

B. An informal solution

The problem discussed in the previous section is caused by the fact that the player of the role is John himself rather than an academic staff role-holder, so that he/she comes back to himself when he/she stops to play a role. If the player of associate professor role was an academic staff role-holder rather than John, then the player of the associated professor role can stay being an academic staff member when he/she stops to play the role. This can be explained from another perspective. That is, this difficulty is caused by the confusion between academic staff role and associate professor roles. The former means that the player of the role is a member of the university (as an academic staff member), and the latter means what the player is expected to perform in the university. The above motivating example and its model fails to capture the separation between an associate professor role which is a composite of the post subrole and a staff member subrole.

As it is already apparent, this problem can be solved by distinguishing between *academic staff role* and *professor/associate professor role*, and using *academic staff role-holder* rather than *person* as the player of the associate professor role as shown in Fig.4.

Firstly, when John is an associate professor of Osaka University, he plays an instance of an *academic staff role* in Osaka University and thereby becomes an *academic staff role-holder* (referred to as RHi). Then, RHi

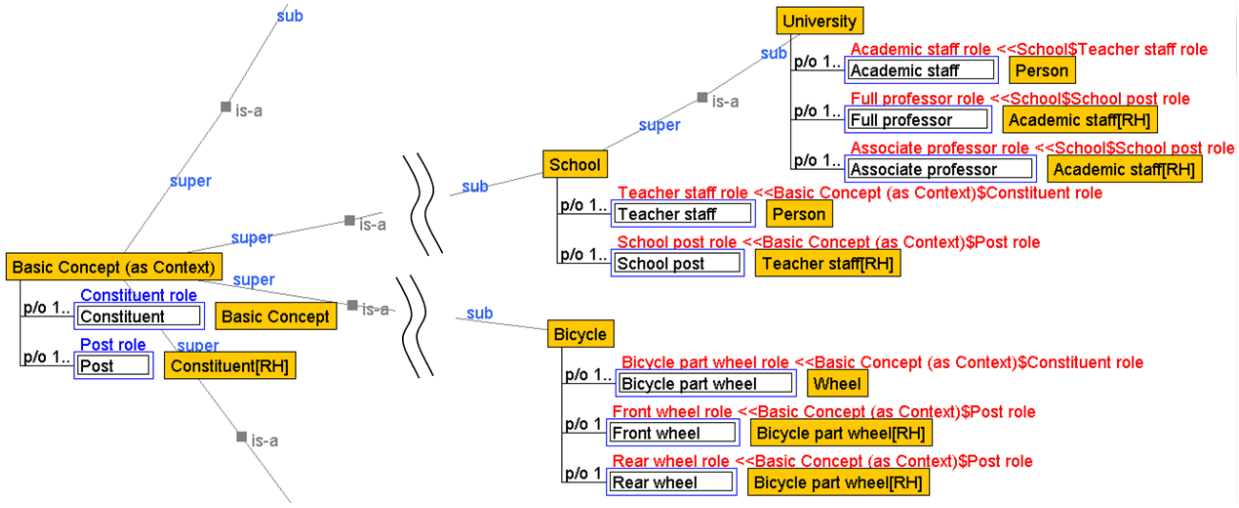

Fig. 6. Class definitions of Constituent role and Part role

plays an instance of *associate professor role* and thereby becomes the associate professor (role-holder). Next, when John is promoted from associate professor to full professor, he (RHi) stops to play the *associate professor role* and plays a *full professor role* while he does not stop to play the *academic staff role*, since he comes back to not an ordinary *person* but RHi which is a role-holder of *academic staff role* when he stops to play the *associate professor role*. This problem is thus resolved successfully.

C. Constituent subrole and post subrole [7]

We generalize the notion of subroles introduced in the above. Fig.5 shows the original framework of our role theory (the upper one) and the extended one (the lower one). In the original framework, a role is simply played by a player. In the new framework, on the other hand, the post subrole is played by constituent subrole-holder which is made of constituent subrole played by a usual player. The original structure is kept and the new one is composed of the original one in a nested structure. As to the structure, we can say that the potential player of the original framework is extended and replaced by constituent subrole-holder.

The ordinary role is decomposed into two subroles: post subrole and constituent subrole. The post subrole represents the main content of the original role and hence is responsible for specifying what job/task is expected to be performed by the player. On the other hand, the constituent subrole is introduced just to represent participation of the player in the context to create theoretically appropriate players of corresponding post subroles. It also contributes to the context by being its component/participant.

Note that this idea of separation of a role into two subroles applies to all kinds of roles defined in the context of an entity as a whole in theory. The utility is apparent in the case of a company in which people often move across departments and get promoted to an upper post. In the example discussed in *B teaching staff role* in a school and *academic staff role* in a university are *constituent subroles*[1] which means their players are participating in the organization (school and university). And, *school post subrole* in a school, *associate professor role* and *full professor role* are *post subroles* which mean roles (posts) are performed in the organization by role-holders of the *constituent subroles*.

We can find the same issue concerning artifacts. For example, suppose that a front wheel of a bike is replaced by a rear wheel in the same bike. The replaced wheels change its role while keeping participation in the context. To capture this case appropriately, we should define *bike part role* as a constituent subrole and some post subroles (e.g. *front wheel role*, *rear wheel role*) played by role-holders of the *bike part roles*. Fig.6 shows examples of them discussed in this section.

D. Instance of role concept

Let us take a teacher John's case in a high school to investigate the role instance problem as an example. Imagine a situation where, after John retired, a new teacher was hired. The question is whether or not the teacher role instance of John was playing is the same as what the new person plays. If there is only one role instance like prime minister role, the answer is trivial. So, the answer of the John's case would be the same role is played by the new comer. However, if two teachers retired at the same time, and two new teachers were hired, then there is no way to identify which role instance is

[1] We can introduce a superrole of them such as member (of the organization) role whose subroles include constituent roles for clerks or students if it is needed. That is, we can define several kinds of constituent roles according to their contexts [7].

played by which. If we think about the case where a student Mike comes back to the same university after he once graduated from it, it is not clear if he plays the same student role as the former one or not.

Our goal here is not to determine in which cases the role instances are reused. We intend to come up with a flexible role instantiation model which can cope with either case so that users can use it as they like. Interestingly, the two roles: *constituent subroles* and *post subroles* do a significant contribution to coping with this issue. In fact, post subrole is created according to each kind of role concepts independently of players. For example, when there are three English and two math teacher roles in a school, one English teacher post subrole and one math teacher post subrole instances are created. On the other hand, constituent subrole instances are created for each player instance. Each post subrole instance is shared by multiple constituent subrole instances and is reused by them. Such roles as prime minister, manager, president and teacher roles attract people's focus on their post subroles, and hence they seem to be reused by multiple players. Even in the case of restaurant guest roles, we create one guest post subrole for a restaurant and reuse it by multiple players (guests) because all the players should be equally treated by restaurant staff as guests.

We know the term "guest post subrole" sounds strange comparing with manager post and president post subroles. However, we believe it is just a terminological problem and does not degrade the idea of post subroles which is applicable to any role.

In the case of constituent subrole, on the other hand, its instance is created whenever a new playing event happens independently of the player is the same or not. So, even if the same player has played the same role multiple times, each instance of the constituent subrole should be different. When people concentrate their focus on constituent subrole, then the role seems to require new instances whenever a new player participates in the context.

When we investigate properties role instances should have, we notice important information is lacking, that is, the information of when the player plays the role. Candidates which can possess such information are the following three: player itself, post subrole and constituent subrole[2]. If we put it to players, then we lose the information when he/she left. Post subroles are shared by multiple constituent role-holders, so it is not appropriate to hold such player-dependent information. *Constituent subroles* are created for each playing event, so it would be the best to let each constituent subrole to possess such information.

In summary, when a context instance is created, all the instances of post subroles corresponding each role kind are created. All post subroles are played by the corresponding constituent subrole-holders which are created whenever a player participates in the context to play the role. All the players participated in the context must play the constituents subroles first and thereby become a constituent subrole-holder to play the post subrole corresponding to the original role. Constituent subroles thus represent participation events of players as well as generic components of the context. The problem of instance generation of roles has been resolved by the introduction of these two subroles. As already explained, post subroles are created according to the corresponding role independently of the existence of players, while each constituent subrole is created according to each participation of a player. Whether the constituent subrole instance should be kept as a vacant role after the player has gone is determined by the necessity of keeping the participation history.

IV. WHAT IS A ROLE?

A role is something to be played. When a person plays a teacher role, he/she must fulfill the requirement the school expects. If it is a math teacher, he/she must be qualified with math teaching. A role is thus a required specification expected to be fulfilled by a player. This view suggests that what a player has when he/she plays the role is capacity to fulfill the role specification. The players realize their capacity to fulfill the specification required to play the role. Therefore, the role is external to the player. What is internal to the player is capacity to realize/fulfill the role as specification. The decomposition of a role into *post subrole* and *constituent subrole* also contributes to the idea of "a role is a specification" because *post subrole* is what a player fulfills after removing *constituent subrole* from the original role and corresponds to what functionality/responsibility for the player to perform/have

Let us investigate the idea that a role is a specification further for each of the cases where roles defined in the context of an object and an occurrent.

(1) Object-dependent roles

Every part of an object contributes to making it as a whole. In the case of functional objects which have functional parts, all parts play a role to help the whole realize its function by performing respective functions. An engine of a car plays a *power source role* by generating torque and a blood vessel of a circulatory system of a human body plays a *conduit role* by allowing blood to flow, etc. Such roles that are associated with parts specify what function(s) must be performed. In particular, parts/components of an artifact are designed as specification which must be satisfied by real parts/components which are installed at the right place with right qualities to realize the real artifact.

(2) Occurrent-dependent roles

[2] The role-holder is the strongest candidates, of course. However, it is a composite of these three, so it is excluded.

Any occurrent necessarily needs participants. Objects can participate in an occurrent. Typical participants are *actor* and *operand* either one of which is a role. Examples of actor role include *runner, singer, speaker, etc.* Actor as a role subsumes these three roles each of which specifies what it must be, that is, *runner role* specifies that its player must participate in a running process as a doer.

The discussion thus far suggests us a temporary answer to the question: what is a role. A role individual exists as a specification as far as its context exists independently of if it is played or not and it exists not in the player but in its context. Players have capacity to fulfill the specification of the role to play. This idea fits the notion of *play* very well. Borrowing Guarino's claim[3], "to play a piece of music essentially means to play an instrument using a musical score which is a specification".

V. VACANT ROLE AND VIRTUAL ROLE-HOLDER

A. Vacant role

At first glance, a role seems to be a property rather than a relation. Although it is true that a role is not a relation, the problem is that a role can be a property only when it is played by an entity. Note here that it is a property of the player rather than so is the role itself intrinsically. This suggests that if a role is a property or not is not a simple problem which is caused by the fact that a role is something to play, and hence there is a situation where a role is not played by anything. Thus, there appears a serious issue: **what a role is when it is vacant**.

To answer this question, we need to investigate what is the instance of a role in the first place: If it is a property, then whose property is it, the player or another? There are two states in roles: being played and not played. If a vacant role, which is not played by any entity, were a property of the player, then the issue would have been much easier as that a role is a property of a player in any case. However, the vacant role cannot exist in the player, but exists in the context where it is defined, which is outside of the player. For example, a teacher role is defined in a school and does not exist in the player when it is not played. Teacher roles are key components of a school which is composed of other roles such as student roles and lecture room roles as well as teacher roles.

How much vacant is a vacant role? We claimed a role is a specification in IV. Then, what is an instance of role as a specification? If it is just a specification, then a vacant teacher role of a school does not make sense well and it does not explain the reality. How about the Japanese Prime Minister role? We do not think it is just a specification when it is vacant. To investigate this issue, here are two stories[4].

> ***Story 1:*** *A letter has been sent to the President of a country from Mr. A who does not know Mr. President resigned a few days ago. The letter is valid and received successfully.*
>
> ***Story 2:*** *A set of cords connected to the right headlight of a car is said to be connected to the right headlight even when the light bulb is taken off.*

Both stories say that a vacant role is not just vacant and is something more realistic than mere specification. In Story 1, even if President cannot answer the letter, it is validly received and the next real President will be able to answer it. In Story 2, engineers talk about the right headlight independently of if the bulb is there or not, though the vacant right headlight cannot light. In short, these vacant roles are almost real entities. So, we call such a vacant role *virtual entity*. Then, the next issue is how to concretize such an observation.

B. Virtual player

This idea suggests a possibility to introduce *virtual role-holder* of constituent subrole to let it play the post subrole. It is anyway effective to let anything play a post role for making a mere specification more realistic. But, we have no real player. Then, the only possible way is to create a *virtual player* who is empty but to let it play a constituent subrole to produce a *virtual constituent subrole-holder*.

Then, what is a virtual player? It is made by removing all the values of specified properties derived from its material part, so that if such an immaterial player already there and play the *constituent subrole* to become a *virtual constituent subrole-holder,* it would resolve our problem. Note, in our case, that we have two virtual role-holders: *virtual constituent subrole-holder* held by a *virtual player* and *virtual post subrole-holder* held by *virtual constituent subrole-holder*.

Accordingly, we modify the idea of role-holder to adapt to the notion of *virtual player*. In the current theory, role-holder instance cannot exist without a player, while, in the new theory, it can exist as a *virtual role-holder* by considering the role is played by a virtual player. When a role is played by a real entity, the corresponding *role-holder* comes to exist as a real entity. Thus, the change of our theory has been made on the treatment of vacant cases. Although the theory needs more adaptation, it is omitted due to space limitation.

We define a ***virtual role-holder*** as a role-holder in the case of the player is a ***virtual player***. See Fig. 7 which shows *virtual teacher-1* is made when a *teacher post subrole* is played by a *virtual constituent-1* which is made when a *constituent subrole* is played by a virtual player,

[3] This captures only meaning of his claim in personal discussion made in the context of EuJoint project: Project n. 247503.

[4] These two stories are given by Nicola Guarino while discussion with him and his colleagues in the context of collaborative research supported by EuJoint: Project n. 247503.

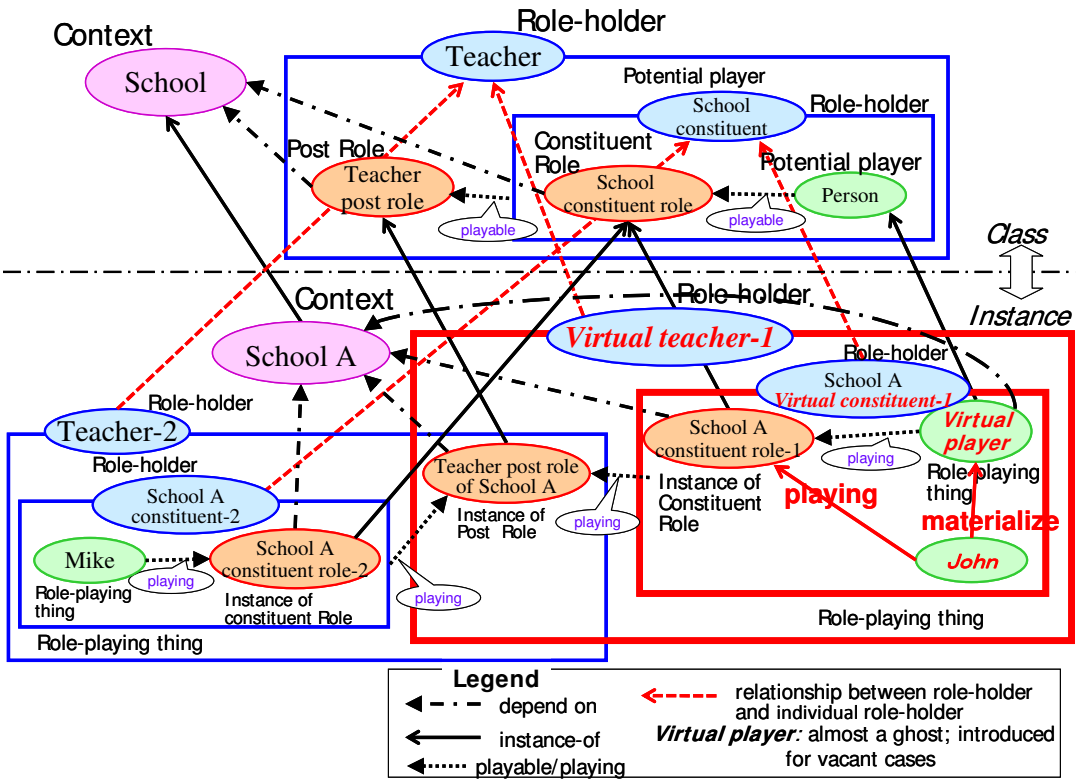

Fig.7 Virtual teacher and virtual constituent (see the two red rectangles).
All circles represent a set of properties.

that is, when no real player exists. When John participates in the context (school A) and plays the teacher role, he **materializes** the virtual player by giving all his property values to it. Then, the next issue is what is the virtual player materialized by John? Are there two different individuals at the same time: John and a virtual player materialized by John? Because the relation between the two is *constituted-of*, the answer is yes, and both of them exist by sharing the same region in the spatiotemporal space like a vase. It is analogous to the case of a vase constituted of an amount of clay. After making a vase using the amount of clay, both keep their identities unless the vase has been destroyed. They co-exist in the same region of the spatiotemporal space. Thus, when a real player participates in the context, the *virtual role-holder* continues to exist even after a real player has participated in, that is, it exists independently of it is filled or not.

In this way, a letter sent to the President who recently resigned is received by the *virtual President role-holder*, and the cords to the right headlight are successfully connected to the *virtual right headlight role-holder*.

The introduction of virtual player does not have to be done to all kinds of roles. It should be dependent on the kinds of roles. It should be introduced to such roles that have a unique individual or pre-fixed number of role individuals. On the other hand, roles whose number of role instances is indefinite like guest role of a restaurant do not need any virtual player.

C. Toward formalization

Although it is very preliminary, the following is a first step towards formalization of role playing and vacancy of roles mainly for cases where virtual players are necessary.

Primitives: *context(x), playing(x, r, rh){x is playing a role r and becomes a role-holder rh}, post-sub-role(x), real(x), virtual(x), constituent-sub-role(x), inherit(x, y) {x inherits all properties of y}, part(x, y) {x is a part of y}, constituted-of(x, y, vo) {x is constituted of y using vo as a template}*

The original model:
role-concept(r, x) => context(x).
role-holder(rh, r) => ∃x,y; context(y), role-concept(r, y), playing(x, r, rh), inherit(rh, x), inherit(rh, r).
role-holder(rh, r) <=> ∃x; playing(x, r, rh).
vacant(r) => Not (∃x; playing(x, r, rh)).

The new (nested) model:
role-concept(r, w) => ∃x,y,z; context(w), part(x, r), part(y, r), post-sub-role(x), constituent-sub-role(y). {x and y are non-overlapping and exhaustive}

c-role-holder(rh, y) =>. x, csr; context(y), role-concept(r, y), part(csr, r), constituent-sub-role(csr), real-playing(x, csr, rh).
p-role-holder(rh, r) =>. x,y, psr; c-role-holder(rh1, r), part(psr, r), post-sub-role(psr), playing(rh1, r, rh). {a psr can be shared by multiple csr's}
vacant(r) <=> Not (x; real(x), playing(x, r, rh)).
v-c-role-holder(rh, y) =>. x, csr; context(y), role-concept(r, y), part(csr, r), constituent-sub-role(csr), virtual-playing(x, csr, rh).
v-p-role-holder(rh, r) =>. x,y, psr; v-c-role-holder(rh1, r), part(psr, r), post-sub-role(psr), playing(rh1, r, rh).
real-playing(x, r, rh) =>. y, vo; real(y), virtual(vo), constituted-of(x, y, vo), playing(x, r, rh), virtual-playing(vo, r, rh).
virtual-playing(x, r, rh) => virtual(x), playing(x, r, rh).
context(x) =>. rh, rh1; v-c-role-holder(rh1, x), v-p-role-holder(rh, r), playing(rh1, r, rh).

VI. Related Work

As far as the authors know, there are few papers which tackle the main topics discussed in this paper except [4]. Existing literature on roles scatters in several areas of ontology engineering [3][11][9,10], database model[16], software engineering [1], and agent systems [2].

Guarino discussed vacant roles and claims that they are more real than the current understanding about them in the role community in his recent paper [4]. We share the same issue with him. He nicely analyzes ontological status of related entities and concepts such as system component, replaceability, functional roles in the context of vacant role (missing player). While he does not present a solution to this issue, we have proposed a solution to the problem in this paper.

VII. Concluding Remarks

We have proposed (1) post and constituent subroles to cope with continuity of role-playing in the case of change of roles, (2) a new view of role as a specification and (3) virtual player. These contribute to refinement of role theory. Future work should be completion of the formalization of the new theory.

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References

[1] Chernuchin, D. & Dittrich, G. (2005): Role Types and their Dependencies as Components of Natural Types, Proceedings of the 2005 AAAI Fall Symposium 'Roles, an Interdisciplinary Perspective: Ontologies, Languages, and Multiagent Systems' Technical Report FS-05-08, Arlington, Virginia, pp.39-46.

[2] Colman,A., & Han, J. (2007). Roles, players and adaptable organizations, Applied Ontology **2** , 105-126.

[3] Guarino, N. (1992): Concepts, attributes and arbitrary relations: Some linguistic and ontological criteria for structuring knowledge bases. Data & Knowledge Engineering **8**(2), 249–261.

[4] Guarino, N. (2013): Artefactual systems, missing components, and replaceability, Chapter 11, Artefact Kinds: Ontological and the Human-Made World. Syntese Library, Springer (to appear).

[5] Kozaki, K. and et al. (2002). An Environment for Building/Using Ontologies Based on a Fundamental Consideration of "Role" and "Relationship", In Proc. of the 13th International Conference on Knowledge Engineering and Knowledge Management (EKAW2002), 213-218.

[6] K. Kozaki, et. al. (2007) Role Representation Model Using OWL and SWRL, In Proc. of 2nd Workshop on Roles and Relationships in Object Oriented Programming, Multiagent Systems, and Ontologies, Berlin, July 30-31, pp.39-46.

[7] K. Kozaki, et. al. (2008) Instance Management Problems in the Role Model of Hozo, Proc. of the 10th Pacific Rim International Conference on Artificial Intelligence (PRICAI-08), LNAI 5351, pp. 614-625, Dec. 15-19, Hanoi, Vietnam,

[8] Kozaki, K., Kitamura, Y. and Mizoguchi, R. (2012). A Model of Derived Roles, In Proc. of the 18th International Conference on Knowledge Engineering and Knowledge Management (EKAW2012), pp.227-236.

[9] Loebe, F. (2005). Abstract vs. Social Roles - A Refined Top-Level Ontological Analysis. Papers from the AAAI Fall Symposium Technical Report FS-05-08, pp. 93-100, USA.

[10] Loebe, F. (2007). Abstract vs. social roles - towards theoretical account of roles, Applied Ontology **2**, 127–258.

[11] Masolo, C., Vieu, L. and et al. (2004). Social roles and their descriptions, In Proc. of the 9th International Conference on the Principles of Knowledge Representation and Reasoning (KR), , 267–277.

[12] Masolo, C, Guizzardi, G., and et al. (2005). Relational roles and qua-individuals, AAAI Fall Symposium on Roles, an interdisciplinary perspective, November 3-6, 2005, Hyatt Crystal City, Arlington, Virginia.

[13] Masolo, C., Vieu, L., Kitamura, Y., Kozaki, K. and Mizoguchi, R. (2011). The Counting Problem in the Light of Role Kinds, InProc. Of AAAI Spring Symposium on Logical Formalizations of Commonsense Reasoning, 76-82.

[14] Mizoguchi, R., Kozaki, K., Sano, T. & Kitamura, Y. (2000). Construction and Deployment of a Plant Ontology. In R. Dieng and O. Corby (Eds.), Proc. of the 12th International Conference on Knowledge Engineering and Knowledge Management (EKAW2000), Juan-les-Pins, France, LNCS 1937, 113-128.

[15] Mizoguchi, R., Sunagawa, E., Kozaki, K. and Y. Kitamura. (2007). The model of roles within an ontology development tool: Hozo. J. of Applied Ontology, **2**, 159–179.

[16] Steimann, F. (2007). The role data model revisited, J. of Applied Ontology, **2** (2007), 89-103.