

# Perdurant Ontology Using Conceptual Dependency Theory

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**Abstract.** Ontology considered as a back bone of the semantic web technology. It is suggested as a solution to enhance the discovery process. Ontology was divided into two entities, endurant and perdurant. Endurants are entities that wholly present at any time at which they exist. Perdurants are entities that happen in time, which described as event or action. Until now there is no standard tools to represent and develop perdurant. In this paper we examine a new representation of perdurant based on the Conceptual Dependency theory, which concerned with the intentional and contextual connections between events and meaning representation for primitive actions.

Keywords: Ontology, Semantic Web, perdurant, endurant, action, Conceptual Dependency, event.

## 1. Introduction

The emergence of the Internet is a real revolution in the field of computer science. It has the capability and tools to spreading information. It's also a medium for communication and interaction between people and their computers without regard for their geographic location.

Now a day's every business or organization is supported by an information system. There are millions of information systems around the world. Since the mid-1990s it has been possible to make these information systems universally accessible via the world-wide web. As stated in [1], the number of world-wide internet users from 2000 to 2015 is 3.17 billion, all these users have different interest in their search but all of them suffering from the result which they had.

Ontologies suggested as a solution to enhance the discovery process. It is considered as a back bone of the semantic web technology which describes the content of the web in a machine readable form, linking data and giving a shared understanding of the terms used to represent entities.

The term ontology defined by Thomas Gruber as "a specification of a conceptualization". Ontology studies the system for knowledge representation in terms of basic concepts and how these concepts are organized in terms of relations, especially in the context of computational representation[2]. This definition adopted to the field of the semantic web.

## 2. Endurant and Perdurant entities

Ontology was divided into two entities, endurant and perdurant. Also called continuants and occurrents which differ in their relation to time. Endurants are wholly present at any time at which they exist. For example, you (an endurant) are wholly present in the moment you are reading this paper, while perdurants extended in time. They are only partially present at any time at which they exist. For example, at this moment only a (tiny) part of your life (perdurant) is present, larger parts of your life –such as your child hood—are not present at this moment [3]. In the BWW(Bunge-Wand-Weber) system [4], endurants are called objects or things such as country, hotel, taxi and company, while perdurants are called events or actions for example, buying and selling.

R.Colomb [5] differentiate between two entities as following:

*"Endurant is an entity which exists in time and can have parts, but all of its parts as at any time are present at that time".* Hence, an endurant can change in time. Ordinary objects are endurants, such as records stored in information systems. On the other hand *"A perdurant or occurrence is an entity which extends in time by accumulating temporal parts. Except for occurrences which exist only at a moment of time, an occurrence is never wholly present. Its past parts are present no longer"*.

Furthermore, the two terms appeared in the two formal ontologies BWW and DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) [6], which are compatible with each other with little differences. In BWW system an endurant is called a thing, while in Dolce called entity.

### 3. Perdurant Representation

According to [7], perdurants are entities that happen in time, which described as event. BWB has concept of history of thing which is an event or a perdurant. An event in BWB is an event in DOLCE, both ontologies having the same concept, but DOLCE divided perdurant into two subclasses: event and stative. An event is definite and if it is complex, it is capable of completion. If it has temporal parts, none of them are of the same kind as the whole, ex. being born, buying, selling, getting married. A stative is indefinite. It can have temporal parts which are the same kind as the whole, ex. sitting, raining, being alive, and being dead.

Our concern in this paper is perdurant (events) rather than the statives one. With reference to Gruber definition of ontology, the world now rely on many entities or endurants having parts represented as ontology of data about certain entities. As cited also in [7], “endurant is created by an event. Its existence is a sort of memory of the happening of the event. Any change in an endurant is created by an event. An endurant is destroyed by an event”.

From this definition, we notice that endurant entities always associated with event, therefore there is a demand for a comprehensive modelling technique to specify both.

Endurant ontologies are represented by the standard UML(Unified Modelling language) class model or OWL(Ontology Web Language), where as perdurant which associated with an endurant must be represented in a languages compatible with these standard. Unfortunately, until now there are no standard tools to represent and develop perdurant ontology. Although most ontology research extensively discussed ontology of data or endurant, there are shortcomings in the perdurant field of research, although it is recognized in the upper ontology.

Our main goal throughout this paper is to find a new representation of perdurant ontology to support understanding the semantic of actions between different participants. This paper focuses on this issue and we will show the related work addressed perdurant representation in the next section.

### 4. Related Work

M.Nazir and R.colomb [7], had an initiative of perdurant representation in their work. They developed a formal ontology for perdurants suitable for IWs (Institutional World’s) in the area of information systems. They used the DEMO (Dynamic Essential Modeling of Organizations) concepts and modified it to represent IWs concepts.

The developed DEMO profile depends on Dietz's theory of DEMO [8] and the theory of speech act. Moreover, they apply many DEMO-representations for IWs and used them for modelling the domain ontology of perdurants such as, actor-role (player), C-fact, P-fact, I-fact (institutional fact), C-

act and P-act (performative speech act), I-act (informative speech act). In summary they developed perdurant ontology using UML profiles for a UML activity diagram based on DEMO system representation. Fig 1 shows this.

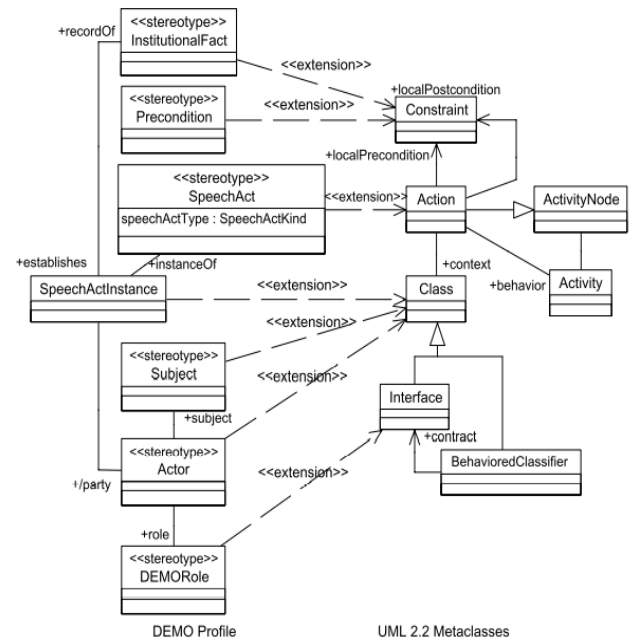


Fig.1:UML profile for DEMO, depicted from [7]

Another study given by A.Ibrahim [9], which proposed a frame work for ontology server that supports both endurant and perdurant ontology for Halal Food Interlocking Institutional Worlds (HFIWs). Hence, they represented endurant using OWL classes, but OWL doesn’t support developing ontology of perdurant, and so UML.

To overcome this limitation of ontology tools representing perdurant, the researchers present the behavioral view of the HFIWs using UML activity diagrams and borrow OWL-S (Ontology Web Language for Services) ontology terms to describe services or actions existed in the domain such as Halal Registration Process and Purchasing Process. OWL-S organizes a service description into four conceptual areas: the process model, the profile, the grounding, and the service. In their work they concentrated only on process models. Fig 2 illustrates this issue.



Fig.2 : Atomic Process Halal Registration Service, depicted from [9]

To compare our work with the two previous studies, neither M.Nazir nor A.Ibrahim giving a solution to represent perdurant instances. Both of them developed a conceptual

model of perdurant using UML profile. This paper uses the Conceptual Dependency theory to represent perdurant as an action .

A.Ibrahim noticed that OWL-S is not suitable for representing perdurant ontologies, because it does not provide representation for perdurant instances, just it provide a description for the web services. Moreover, the tool represents services as a black box without showing service tasks. In addition to that OWL-S takes a service point of view to describe service activities, so it is oriented to services in service-oriented architecture rather than representing perdurant ontology.

## 5. Conceptual Dependency (CD) Theory

The Conceptual Dependency (CD) theory [10] given by (schank and Abelson,1977), is an old theory which provides a meaning representation for action or event. It was concerned with the intentional and contextual connections between events, especially as they occur in human purposive action sequences. The theory has two basic axioms:

- a) For any two sentences that are identical in meaning, regardless of language, there should be only one representation.

Principle A forces us to look closely at actions that seem similar to see if we can extract the essence of their similarity.

- b) Any information in a sentence that is implicit must be made explicit of the representation of the meaning of that sentence.

Principle B forces us to make explicit whatever differences there might be between two actions and to express them accordingly. For example, two verbs in a language may share a similar primitive element such as “give” and “take” share the primitive element transfer of possession, but also have differences.

The following framework was invented for representing meaning. The meaning prepositions underlying language are called conceptualization. A conceptualization can be *active* or *stative*.

- a) An active conceptualization has the form:  
Actor Action Object Direction (Instrument).
- b) A stative conceptualization has the form:  
Object (is in) State (with value).

More details about the theory are given in the Appendix.

## 6. Perurant Ontology using CD Theory

To examine the usefulness of CD theory to represent perdurant, we discussed perdurant with a real case study on queries sent to Trip Advisor web site from different traveler’s [11] .

### 6.1. Trip Advisor (Case Study)

Trip Advisor is web site helping travelers to organize their trips. The players participating in the site are:

- Travelers who asked for advices to organize their own travel.
- Countries and their Cities.
- Hotels, Restaurants.
- Airlines, Embassies, Exchanges.
- Taxi companies, Tourism Companies.
- Vacation rentals, Car Hire companies and Drivers.

Travelers ask how to organize their trips to specific city, starting from booking to the preferred flight, hotel price and location, restaurants available in the city and foods they offer. They check the availability of the visa to another country from their current locations, exchanging their money, renting apartment, taxi fares and driver information, tourism companies existing in the city, hire a car, and many things to do in a city. The site allows travellers to get advices from the experience reviews in the site which stored in the traveller’s form and used to plan their next trip. The site provides many services to travellers such as hotels, flights, vacation rentals and restaurant.

Accessing these services through the search engines is very difficult. If you intend to travel, you will interact with multiple information systems available on the web. However, this type of interaction would be very difficult with the current search engines because we have a huge number of travellers around the world speaking multiple languages and using different type of queries to ask about different services which are embedded in the distributed information systems. Information stored in these types of systems is scattered.

Hence, it is very difficult for queries made by agents to produce a good result. For example if we use google search engine as an example to search about specific hotel in a city like: “sofaraa al huda hotel madinah” we would have 10,100 results with limited precisions and limited recalls, this is depicted in Fig 3.

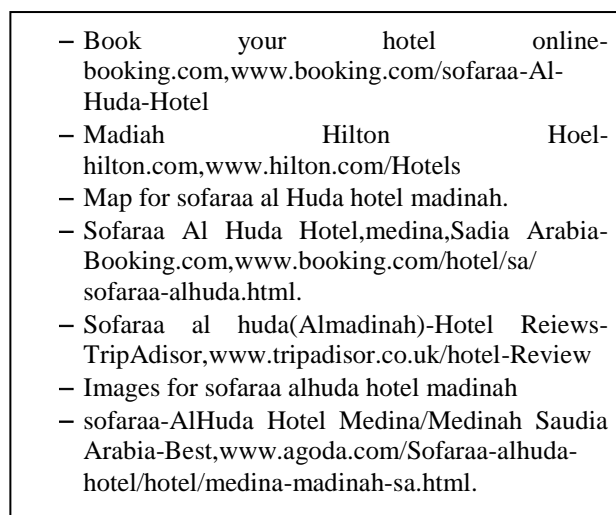


Fig. 3: First Page of Result From Google Search For “sofaraa al huda hotel madinah”.

An important issue arises from the type of user’s queries. Because, travelers send query to plan and manage their next travel based on the previous experiences or stories told by

former travelers. This kind of information is not part of any information systems but it presents a knowledge base in traveler's brains. All these stories are including actions to be performed to manage specific travelling event.

R.Colomb [5] stated that, "for a group of systems (information systems) to interoperate, the organizations responsible for the systems must first agree on what the words mean in the interoperation. This agreement is called ontology, a description of the world shared by the participants". According to this sense we need to develop ontology for Trip Advisor web site, since it has different information systems share the site.

Endurant ontology is represented by the OWL language. Endurants are entities that exist in time such as records stored in information systems, like the information about any driver, flight or hotels and so on. The ontology designed with TopBraid Composer tool [12] as depicted in Fig 4.

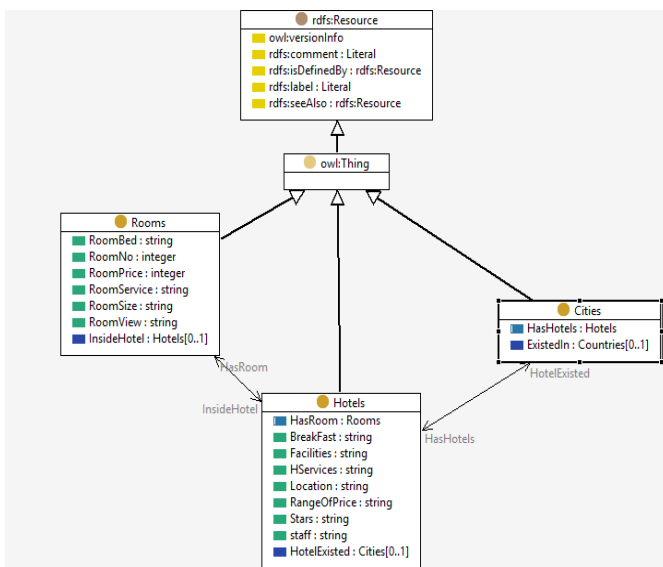


Fig. 4: Part of Endurant Ontology of TripAdvisor Website

### 6.1.1. Perdurant Representation

In this section we will show some traveler's queries. The answers for these queries are background experiences and practices that are not stored in the information systems. If traveler inquires about travelling services that had been done by a former traveler, then the answer of this query will be given by different stories about travelling to that country. The results are advices in a form of actions to do something or perdurant entities. Queries obtained from our case study are presented in the following Tables (1-4):

TABLE 1. Query1 to Organize a Trip

Q1	How to organize a trip from Khartoum to Wadi Halfa ?How safe is this area? Has anyone done this? Any suggestions.
	Khartoum to Wadi Halfa is a safe journey, just make sure you go with a reputable travel agent and all paperwork are in order. There are a lot of military checkpoints but all you need to show is a copy of your passport with valid entry visa. Keep the original in a safe place.

TABLE 2. Query2 Stroller in Umrah

Q2	I am planning to fulfill my umrah in April 2014 InshaAllah, I will be travelling with my 15 month old daughter. Please advise whether I should take a stroller with me or not?
	Congratulations on your intentions of doing Umrah. You can bring the stroller with you but it would be quite a hassle inside the haraam. There are safety deposit boxes available outside haram where you can leave the stroller if you like, but I think they charge 10 or 20 riyals for 4 hours or so.

TABLE 3. Query3

Q3	In October 2014 we will be flying into Terminal 5 from Toulouse and will need to get to Terminal 2 to catch our flight back to Australia. However the Heathrow website does not yet include how to get to Terminal 2 from any other terminal.I need to book our flights from Toulouse so need to know how long it will take to get from T5 to T2. Can anyone help please ?
	T2 is located in the central terminal area and is between T1 and T3. For an airside connection (one ticket) you'll take a shuttle bus from T5 Flight Connections to T2, reclear security and proceed to your gate. For all intents and purposes, you can treat this as a T5-T1 or T5-T3 connection on this link : <a href="http://heathrowairport.com/heathrow-airport-guide/f...">heathrowairport.com/heathrow-airport-guide/f...</a>

TABLE 4. Query4

Q4	planning my first trip to dubai next week - so quite anxious! can I use my Standard Bank card at the ATMs? any ATM? are the exchange shops easy to find in the malls? If I carry cash should it be in dirham or dollars? by SA
	Check the symbol on your ATM card to make sure there is a corresponding symbol on the machine.Exchange shops in the malls are easy to find.EXCHANGE HOUSES IN THE MALLS - As explained above these have the best rates, but always check to see which house has the best rate on that particular day. Rates are updated (maybe) several times a day to reflect moves of the international currency markets.Carry cash in dirham.

In Query1 traveler need advices to organize a trip from Khartoum to Wadi-Halfa and if it is a safe place for travelling?. The answer mentioned that the journey is "safe" and giving some advices to make this journey:

- **Go with** travel agent
  - Paperwork are in order
- The answer also gives advice on the security checking, like:
- **Show** a copy of passport
  - Valid entry visa

From this context we have two actions (Go with, Show) and two states (*In order,valid*). Our concern is to represent

those types of actions using the concept of perdurant ontology.

In this section we give meaning representation for all actions using Conceptual Dependency theory. The following Tables (5, 6, 7 and 8) depict the meaning representation of answers using the CD theory as illustrated in the appendix.

TABLE 5. Representation of Query1

The Sentences	The Meaning
Is a <i>safe</i> journey.	Journey <b>HEALTH</b>
<i>Go with</i> travel agent	<i>Go with</i> : Object <b>PTRANS</b> with object Travelers <b>PTRANS</b> Travel agent
<i>Ordered</i> paper.	Paper <b>PHYSICAL STATE</b>
<i>Show</i> a copy of your passport	<i>Show</i> : Object <b>MTRANS</b> information to object. Travelers <b>MTRANS</b> passport to military checkpoint.
<i>Valid</i> visa.	Visa <b>PHYSICAL STATE</b>

TABLE 6. Representation of Query2

The Sentences	The Meaning
You can <i>bring</i> the stroller with you	<i>Bring</i> : object <b>ATRANS</b> something with himself. Traveler <b>ATRANS</b> stroller.
There are <i>safety</i> deposit boxes	Boxes <b>HEALTH</b>
Available <i>outside</i> Haram	Not represented
You can <i>leave</i> the stroller	<i>Leave</i> : object <b>ATRANS</b> something to place. Traveler <b>ATRANS</b> stroller outside haram.
They <i>charge</i> 10 or 20 Riyals for 4 hours.	Not represented

TABLE 7. Representation of Query3

The Sentences	The Meaning
T2 is <i>located</i> in the central terminal area	<i>Located</i> : object <b>MTRANS</b> place from LTM to SPEAK Traveler <b>MTRANS</b> central terminal area
T2 is <i>between</i> T1 and T3	<i>Between</i> : object <b>MTRANS</b> two places from LTM to SPEAK Traveler <b>MTRANS</b> T1 and T2
<i>Take</i> a bus from T5 flight connections to T2	<i>Take</i> : object <b>PTRANS</b> something from place1 to place2. Traveler <b>PTRANS</b> bus from T1 to T2.
<i>Re clear</i> Security	<i>Re clear</i> : object <b>PTRANS</b> to place and <b>MTRANS</b> something. Traveler <b>PTRANS</b> to security office and <b>MTRANS</b> passport.
<i>Proceed</i> to your gate	<i>Proceed</i> : object <b>PTRANS</b> to place. Traveler <b>PTRANS</b> to gate.

TABLE 8. Representation of Query4

The Sentences	The Meaning
<i>Check</i> the symbol on your ATM card.	<i>Check</i> :object <b>MTRANS</b> something. Traveler <b>MTRANS</b> the symbol.
<i>Make Sure</i> there is a corresponding symbol on machine.	<i>Make Sure</i> : object <b>MTRANS</b> information from CP with another information. Traveler <b>MTRANS</b> ATM symbol with machine symbol.
Shops in the malls are easy to find.	Not represented
EXCHANGE HOUSES have the best rates	Not represented
<i>Check to see</i> which house has the best rate in a day.	<i>Check to see</i> : object <b>MTRANS</b> more than information and select the best one. Traveler <b>MTRANS</b> rate.
Rates are <i>updated</i> several times a day.	<i>Updated</i> : object <b>PROPEL</b> with new information. Rates <b>PROPEL</b> with new rate

From the above representation, we notice that some sentences like (Safety,Ordered) are states (HEALTH , PHYSICAL STATE) of the objects ,whereas the other are actions.

## 7. Discussions

The CD theory was able to express different meaning of actions in one semantic form, such as (Show, Located, Between, Check, Make Sure, Check to see), represented by MTRANS act, which is the transfer of mental information between animals or within an animal from conscious process cp (or where something is thought of) or the LTM(long term memory).The second act is PTRANS, which is the transfer of the physical location of an object, representing (Go with ,Proceed, Re clear, Take) acts.

Consequently, every traveler had his own semantics to the same action, such as MTRANS act has more than one meaning representation depending on the context of the sentence. Hence, we need to build that type of ontology to support semantic sharing for multiple actions.

In summary ,the theory succeeded to represent normal action such as see, go, check, show, get, imagine...etc, and couldn't represent some of them like eat, touch, wearing, make, collect, decide. The theory fails to represent non-continuous English verbs such as to be, to want, to cost, to need, to care, to fear...etc, and be careful, be attention, close to, take longer...etc, also the theory not succeed to represent emotional or feeling verbs such as enjoy, happy, love, hate, sad, great, lucky, smell, sound, taste...etc.

Feeling verbs such as enjoy, happy, love, hate, sad, great, lucky, smell, sound, taste...etc

## 8. Conclusion

This study presents a novel work to represent perdurant ontology or ontology of actions. The study taken a real queries including actions in their answers given from a global and shared web site (Trip Advisor) about travelling , The study uses the Conceptual Dependency theory to represent actions and giving semantic to these types of actions to support semantic sharing within different user's. Moreover, the theory succeeds to represent primitive actions and fails to represent other types of actions verbs such as emotional verbs or adjectives verbs.

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## Appendix

TABLE 9. CD theory States

State	Meaning
HEALTH	dead, diseased, under the weather, tolerable, in the pink.
ANTICIPATION	Terrified , nervous, hoping ,confident
MENTAL STATE	broken, depressed, all right, happy, ecstatic
PHSICAL STATE	end of existence, damaged, ok, perfect
AWARENESS	Dead, unconscious, asleep, awake, keen

TABLE 10. Primitive ACTs of CD theory

Act	Meaning
ATRANS	The transfer of an abstract relationship such as possession,ownership or control.Thus one sense of 'give' is ATRANS something to some else;a sense of 'take' is ATRANS something to oneself;'buy' is made of two conceptualizations that cause each other,one an ATRANS of money,the other an ATRANS of object being bought.
PTRANS	The transfer of the physical location of an object.thus 'go' is PTRANS onself to a place; 'put' is PTRANS of an object to place.
PROPEL	The application of physical force to an object;is used whenever any force is applied regardless of whether a movement (PTRANS) took place.in English 'push,'pull','throw','kick' have PROPEL as part of them.Do indicates an unknown ACT, most of time the ACT that fills in the DO is PROPEL although this is certainly not necessarily the case.
Move	The movement of a body part of an animal by that animal .Move in nearly always the ACT in an instrument conceptualization for other ACTs. That is in order to 'throw' it is necessary to MOVE one's arm. Likewise MOVE foot is the instrument of 'kick' and MOVE hand is often the instrument of the verb 'hand'. MOVE is less frequently used non instrumentally, but 'kiss, 'raise your hand', 'scratch' are examples
GRASP	The grasping of an object by an actor. The verbs 'hold', 'grasp', 'let go' and ' throw' involve GRASP or the ending of a GRASP.
INGEST	The taking in of sn object by animal to the inside of that animal. Most commonly the semantics for the objects of INGEST ( that is, what is usually INGESTed) are food, liquid, and gas. Thus, 'eat', 'drink', 'smoke','breathe', are common examples in INGEST.
EXPEL	The expulsion of an object from the body of an animal into the physical world. Whatever is EXPELed is very likely to have been previously INGESTed. Words for excretion and secretion are described by EXPEL. Among them,' sweat', 'split' and cry.
MTRANS	The transfer of mental information between animals or within an animal.we partition memory into two pieces. The cp(conscious processor where something is thought of) .and the LTM(long term memory where things are stored).The various sense organs can also serve as the originators of an MTRANS.Thus 'tell' is MTRANS between people.'see' is MTRANS from eyes to cp,'remember' is MTRANS from LTM to cp.'learn' is the MTRANSing of new information to LTM.
MBUILD	The construction by an animal of new information from old information. Thus 'decide','conclude', 'imagine','consider' are common examples of MBUILD.
SPEAK	The actions of producing sounds.Many objects can SPEAK ,but human ones usually are SPEAKing as an instrument of MTRANSing.The words 'say','play music','purr','scream' involve SPEAK.
ATTEND	The action of attending or focusing a sense organ towards a stimulus. ATTEND ear is ' listen', ATTEND eye is 'see'and so on. ATTEND is nearly always referred to in English as instrument of MTRANSing . Thus, in Conceptual Dependency, 'see' is treated as MTRANS to cp from eye by instrument of ATTEND eye to object.