

Logic, Knowledge and Time

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In my talk I am going to consider the problem of implementing formal logic apparatus to represent and investigate knowledge undergoing changes in time. By 'formal logic apparatus' we understand systems which are a combination of epistemic modal logic systems applied in the description of knowledge and temporal logic systems which enable the expression of the temporal context.

In the first part of my talk we will discuss basic systems of modal epistemic logic. We supply a basic notional apparatus of modal epistemic logic concerning knowledge of a singular cognitive subject and the notional apparatus connected with issues of knowledge of groups of cognitive subjects. Formal languages considered here are appropriate for the description of static knowledge which is not subject to changes.

In the next part of my talk we will consider the problem of methods of temporalizing logical systems. Two basic methods of temporalization will be discussed: *internal temporalization* and *external temporalization*. Due to its possibilities for implementation we will concentrate on the method of external temporalization. We will describe the fusion method and the Finger-Gabbay method [1] and indicate conditions which should be met so that when joining two logical systems using the mentioned methods, the newly created logical system retains the metaproperties of the components systems. We have in mind here properties such as consistency, completeness and decidability. We will also discuss some systems of temporal-epistemic logic created by use Finger-Gabbay method of temporalization of logic systems [3].

In the last part of my talk we will discuss alternating time temporal epistemic logic *ATEL* [2]. The language of *ATEL* is the language of *ATL* extended with knowledge modalities. Combining knowledge modalities with *ATL* it becomes possible to express some interesting properties of multiagent systems. The *ATEL* logic is defined with respect of finite set of Π atomic propositions and finite set of Σ ($= \{1, \dots, k\}$) agents (players). There are introduced two additional specific operators: $\langle\langle \Gamma \rangle\rangle$ and $\llbracket \Gamma \rrbracket$. The intended interpretation of a formula $\langle\langle \Gamma \rangle\rangle \varphi$ is that the agents Γ can cooperate to ensure that φ holds (or equivalently, that Γ have a winning strategy for φ). The intended interpretation of a formula $\llbracket \Gamma \rrbracket \varphi$ is that the agents Γ cannot avoid φ . Formulae of *ATEL* are interpreted with respect to the alternating epistemic

transition systems.

We will discuss an axiomatization of *ATEL* (it inherits the *S5* axioms of normal modal logic for knowledge modalities and the associated axioms for common and group knowledge). Moreover, we will discuss some applications of *ATEL* in communication and game theory (to describe and analyze of extensive games and formulate backward induction method in the language of *ATEL* [3]).

References

- [1] FINGER MARCELO, GABBAY D. M., *Adding a temporal dimension to a logic system*, Journal of Logic, Language and Information, 1992; 1(3): 203–233.
- [2] VAN DER HOEK W., WOOLDRIDGE M., *Cooperation, Knowledge and Time: Alternating-time Temporal Epistemic Logic and its Applications*, Studia Logica, 2003; 75(1): 125–157.
- [3] SUROWIK D., *Logika, Wiedza i Czas. Problemy i metody temporalno-logicznej reprezentacji wiedzy*, Białystok, 2013, (in Polish).