A Modal View on Polder Politics

Wouter van Atteveldt, Stefan Schlobach

Vrije Universtiteit Amsterdam, The Netherlands

{wva,schlobac}@few.vu.nl

Abstract

To get a better understanding of the influence of the media on current political events, researchers in Communication Science have recently reported on several case studies, in which they analyse certain patterns in newspaper articles, such as internal disagreement or criticism within a political party. In this paper we explain how Hybrid Logic can be used as a query language in such an analysis, and show that we can use existing model checkers to reproduce results of a recently published case study about the Dutch election campaign in 2002. [1]

1 Introduction

The media play an increasing role in the functioning of our society, often being the main informant of citizens and policy-makers. Controversies easily arise when the media are accused of providing inaccurate or biased information, such as the BBC-affair leading to the suicide of David Kelly in the UK and the alleged demonisation of Pim Fortuyn before his assassination in the Netherlands. The messages of politicians reach most citizens through the media rather than directly, making the media image of a party or candidate and their reported positions on key issues an important factor in election campaigns. Therefore, it is important to analyse the content of the media and its effects on media consumers, as done in for example election studies, agenda setting, and framing research (3; 11). These studies generally annotate news items using Content Analysis which has resulted in a large number of annotated articles over the past decades.

In this paper we provide a uniform representation of these media data by formalising them as Kripke structures. Not only do we get unified representations with formal semantics, we also inherit well studied query languages in the form of modal logics. This allows us to use off-the-shelf model checking

[1] The Polder model is a phenomenon in politics in the Netherlands to reach an agreement despite differences, however great these might be.(15)

software to query newspaper articles, or at least the formalisation of these articles. In order to reproduce recent results of a media study about the Dutch elections in 2002 (9), we show that quite expressive modal languages (such as Hybrid Logic $H(@, \downarrow)$) are needed to capture important political terms, such as internal debate or criticism. This approach is verified experimentally by transforming around 7,500 newspaper articles into Kripke structures. Using an existing hybrid logics model checker (6), we query a number of politically interesting patterns and compare them to the original study in (9).

There are three significant advantages of our approach: it offers an explicit semantics for the formal representation of newspaper documents, which makes the study much more transparent and therefore reproducible. Secondly, by using existing tools, the amount of purpose-written and ad-hoc software is greatly reduced, and, finally, it becomes straightforward to integrate formally represented background knowledge.

2 Analysing the News

Quantitative Content Analysis is a field of Communication Science that analyses media messages by categorising units of text into scientifically relevant concepts (10). Network or Relational Content Analysis methods, such as the NET method described below, additionally construct a network from these texts where the nodes are the categories mentioned above and the vertices determine certain relations between these nodes as expressed in the text (12; 5). These relations are often of a fairly subjective or opinionative nature, such as (dis)like between actors and issue positions, but can also include causal relations or actions, such as passing a law or going on strike.

In this paper, a simplified version of the Network Content Analysis method called the NET method will be used. The NET method (Network analysis for Evaluative Texts; 9), assumes that all relevant information in a sentence can be expressed as ⟨`subject`, `relation`, `object`⟩ triples. The `subject` and `object` of these statements are drawn from a (generally fixed) list of relevant concepts, and the `relation` is a binary predicate indicating dissociation or association.

Automatically extracting these relations from text is an open problem on the intersection of Communication Science and Computational Linguistics. A full discussion of this is beyond the scope of this paper; the interested reader is referred to (14; 13) for two examples of work in this field. In this paper we assume that we have such a network to start with, either from one of the many manual studies, or from a (future) automated analysis.

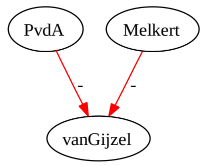
The resulting network can be queried in different ways depending on the research question. In general, the researcher (implicitly) defines relevant concepts as patterns over these networks. In election studies, such as the study that provided the data underlying this paper, it is interesting to know what the general tone and type of the news is, who is portrayed positively or negatively, and what issue positions the different actors have according to the media. Moreover, more specific concepts such as internal dissent, unclear issue positions and criticism from political actors can also be important (9).

2.1 NET by example: the Rise and Fall of Fortuyn

The examples in this paper are all drawn from the media coverage of the 2002 parliamentary elections in the Netherlands as described in (9). Initially, these elections appeared to become a duplicate of the 1998 polarisation between the ruling parties, the PvdA (labour) and VVD (conservative), with both criticising each other but generally intending to continue the coalition. The PvdA, however, was hindered by internal dispute, as exemplified in an article published in the Dutch newspaper "Trouw" on 27 November 2001. Figure (1) shows two sentences of this article which are indicative of this internal strife, and which are coded as ⟨`Melkert`,–, `vanGijzel`⟩ and ⟨`PvdA`,–, `vanGijzel`⟩.

Fig. 1: 'Rob van Gijzel fights back' *(Trouw, 27 November 2001)*

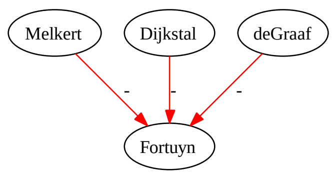
PvdA-leader Melkert took away the spokesmanship on the construction fraud affair from Rob van Gijzel. [..] This shows that he can no longer assume support within his party



Not all went as expected by the ruling parties. On 9 February 2002, the newcomer Pim Fortuyn gave an interview in de Volkskrant which caused him to be seen as extreme right, and forced him to establish his own party to continue in Dutch politics. These radical issue positions caused him to receive heavy criticism from the established parties. The sentences quoted in figure 2 are all direct criticism on Fortuyn by the other party leaders ⟨`Dijkstal`,–, `Fortuyn`⟩, ⟨`Melkert`,–, `Fortuyn`⟩ and ⟨`De Graaf`,–, `Fortuyn`⟩. Note, that any meaningful interpretation of this graph requires some background knowledge, for example, that Dijkstal, Melkert and De Graaf were the party leaders of the VVD, PvdA and D66 at the time.

Fig. 2: "Public urinator" *(Trouw, 13 February 2002)*

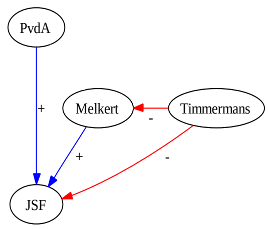
[Before the interview] people had some second thoughts about Fortuyn, but now he is said to 'encroach on the heart of our civilisation' (Dijkstal), 'have crossed a line, that you cannot cross' (Melkert) [..]. De Graaf could not help citing Anne Frank and calling him a fascist and a racist.



Fortuyn did surprisingly well in the local elections in Rotterdam later that month, which caused the leader of the PvdA, Melkert, to come under heavy fire. Moreover, the PvdA was still plagued with internal disagreement, for example about the participation in the Joint Strike Fighter project (Figure 3). The first sentence is coded as ⟨`Timmermans`,−, `JSF`⟩, ⟨`PvdA`,+, `JSF`⟩, the second as ⟨`Timmermans`,−, `Melkert`⟩ and ⟨`Melkert`,+, `JSF`⟩.

Fig. 3: 'Difficult, but I never threatened to resign' *(de Volkskrant, 10 April 2002)*

PvdA parliamentary Frans Timmermans remains skeptical about the JSF decision of his party [..] after the PvdA-fraction finally said 'Yes' to the JSF. Timmermans played the main part and diametrically oppose party leader Melkert on this issue



The tragic end of the campaign is known: Pim Fortuyn was assassinated nine days prior to the elections. His party (the List Pim Fortuyn) made an unprecedented debut and was made part of the government, but it was plagued by internal dissent over the succession and was diminished in the next election after the cabinet fell, less than three months after its formation.

2.2 Healthy Conflict or Internal Dissent

In campaign time, conflict and criticism are the rule rather than the exception. However, there is an important distinction between different types of conflict: conflicting or disputing issues with opponents can be beneficial as it allows a party to create a distinct profile. Internal criticism, however, is generally harmful, as is criticism from societal actors. Also, if different members of a party adopt opposing viewpoints on an issue, the position of the party is unclear to the voter and can be seen as indicating internal dissent or lack of leadership.

Thus, it is important to identify whether the criticiser is a member of the same party or a different party, and whether opposing viewpoints are adopted by members of different parties or of the same party. This means we need to know the party membership of the actors that are under investigation. Using this background knowledge, we can see that figure 1 indicates *internal criticism*, figure 3 indicates *internal disagreement*, while figure 2 indicates *criticism by opponents* of Fortuyn. These concepts are therefore defined as patterns over a combination of media data and background knowledge.

3 Querying opinions through model checking

In the previous section we introduced a prototypical problem exemplifying the way social scientists use information about opinions to analyse political situations. We now show that NET graphs can be mapped to particular Kripke structures, and that hybrid modal languages are useful query languages over these structures. In particular, we show that we can reformulate the case study of the previous section as a hybrid model checking problem.

Not only can we reproduce the published results with our approach, as will be shown in the following section, but the expressiveness of the querying languages allows one to extend the complexity of possible sociological analysis of the underlying newspaper articles. Furthermore, it provides a formal interpretation to the experiments. Moreover, it makes it easier to do meta-research over different communication scientific studies by formalising the semantics and hence allows for improved theory building.

3.1 NET graphs and background knowledge

In section 2 we loosely introduced NET graphs as a result of a specific method of content analysis. These graphs can be characterised more formally as follows: let $\mathcal{N} = \{n_1, \ldots, n_l\}$ be a finite set of names, which usually represent political actors, groups and issues. A *NET graph* is then defined as a finite set of triples $\langle n_i, *, n_j \rangle$, where $n_i, n_j \in \mathcal{N}$ are names, and $* \in \{+, -\}$ is an opinionated relation, denoting consent and dissent, respectively. As an example, consider the NET graph NET_{ex} which was introduced to exemplify internal disagreement between two members of the same party, and which is repeated on the left-hand side of figure 4. Here, we have four names, Melkert, Timmermans, PvdA and JSF, with triples ⟨`Timmermans`,–, `JSF`⟩, ⟨`PvdA`,+, `JSF`⟩, ⟨`Timmermans`,–, `Melkert`⟩ and ⟨`Melkert`,+, `JSF`⟩.

Background knowledge is usually given as a simple ontology over political actors and concepts. Formally, let $\mathcal{N}$ again denote the set of names, $\{R_1, \ldots, R_n\}$ a finite set of binary relations, and $\mathcal{P} = \{P_1, \ldots, P_m\}$ a finite set of propositional variables. The *domain ontology* $\mathcal{O}$ is then defined as a finite set of axioms of the form $(n_i : P)$, $P \sqsubseteq Q$ or $R(n_i, n_j)$, where $n_i, n_j \in \mathcal{N}$, $\{P, Q\} \subseteq \mathcal{P}$ and $R \in \{R_1, \ldots, R_n\}$. In our example, both Timmermans and Melkert are politicians, and members of the PvdA, which is a party, and the JSF is an issue; finally, politicians and parties are political actors. This can be represented formally in the ontology $\mathcal{O}_{ex}$ = {Timmermans:Politician, Timmermans:memberOf PvdA, Melkert:Politician, Melkert:memberOf PvdA, JSF:Issue, PvdA:Party, Politician ⊑ PolActor}.

3.2 NET as Kripke structures

Kripke structures over a set of propositional variables $\mathcal{P}$, are triples of the form $\langle M, \mathcal{R}, V \rangle$, where M is a set of states, $\mathcal{R}$ a family of binary accessibility relations on M, and V is a valuation function from $\mathcal{P}$ to the power-set of M. We can translate a NET structure NET and background ontology $\mathcal{O}$ in the form described above into a kripke structure as follows:

For each name n_i in $\mathcal{N}$, we create a state m_i in M. Let us define two relations $\mathcal{R}_+$ and $\mathcal{R}_-$, where $(m_i, m_j) \in \mathcal{R}_+$ iff $\langle n_i, +, n_j \rangle \in NET$ and an

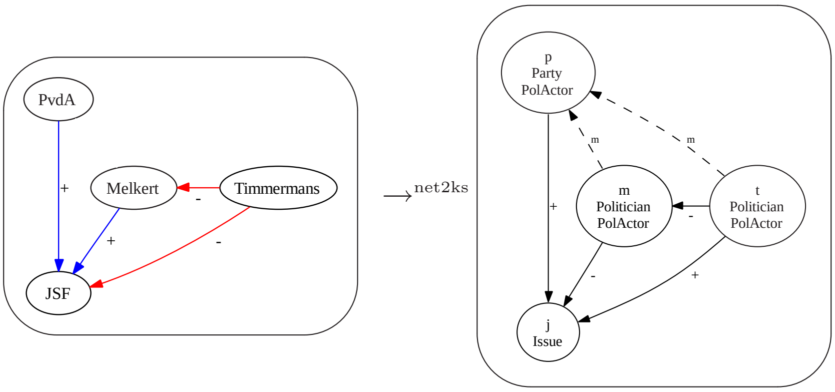


Fig. 4. The NET graph of figure 3 and its Kripke structure $\mathcal{K}_{ex}$

analogous definition for $\mathcal{R}_-$. Further, we define a relation $\mathcal{R}_i$ for each relation R_i in the ontology $\mathcal{O}$, where $(m_i, m_j) \in \mathcal{R}_i$ iff $(n_i, n_j) \in R_i$. Now, we can equate $\mathcal{R} = \{\mathcal{R}_-, \mathcal{R}_+, R_1, \ldots, R_n\}$. Finally, we define the valuation function V as the smallest set $V(P)$ such that $\{n \mid n : P \in \mathcal{O}\} \subseteq V(P)$ and $\bigcup_{(P \sqsubseteq Q) \in \mathcal{O}} V(Q) \subseteq V(P)$ for each $P \in \mathcal{P}$.

Please note that the way we translate the $P \sqsubseteq Q$ ontological statements into our valuation function effectively means unfolding these axioms into propositional symbols attached to the states, which is an implicit Closed World Assumption. This is a necessary assumption if we wish to use a model checker to evaluate formulas, as a model needs to have all valuations specified. Moreover, we feel that in our application this is an acceptable assumption because of the restricted domain.

Now, we apply this translation to the NET graph NET_{ex} and the ontology $\mathcal{O}_{ex}$. From the set of names $\{Melkert, Timmer, PvdA, JSF\}$ we create the set of states $M_{ex} = \{m, t, p, j\}$. The family of accessibility relations is defined as $\mathcal{R}_{ex} = \{\mathcal{R}_-, \mathcal{R}_+, R_m\}$, where the set of NET triples is translated into the definition of $\mathcal{R}_+ = \{(p, j), (m, j)\}$ and $\mathcal{R}_- = \{(t, j), (t, m)\}$; and the ontological relation $memberOf$ is translated into $\mathcal{R}_m = \{(t, p), (m, p)\}$. Finally, the valuation function V_{ex} is derived from taking the instances and unfolding the 'subclass' relation in the ontology: $V_{ex}(Politician = \{t, m\}$, $V_{ex}(Party) = \{p\}$, $V_{ex}(PolActor) = \{t, m, p\}$, and $V_{ex}(Issue) = \{j\}$. This yields the Kripke structure $\mathcal{K}_{ex} = \langle M_{ex}, \mathcal{R}_{ex}, V_{ex} \rangle$ visualized on the right hand side of figure 4.

This translation might seem to be mainly a change from normal to calligraphic font, i.e. the syntactic translation is hardly enervating. However, with this translation we also define the semantics of the joint network of NET and the background ontology. Since NET has no formal semantics attached to it, and no previous work exists to provide a formal framework for interpreting the (social scientific) background knowledge, this is a conceptually interesting and important step. It is worth mentioning that this semantic explicitation is based on a number of assumptions that Social Scientists might agree upon or not. But by providing an explicit semantics to NET (with background knowledge) by means of a translation into Kripke structures we introduce a formal way of interpreting communication scientific concepts or theories. This can provide insight into the (often implicit) discrepancies between the assumptions behind studies.

3.3 Modal logics as query languages over Kripke structures

Interpreting NET graphs and their domain ontologies as Kripke structures has two big advantages: first, it provides a unified representation about all the knowledge that is represented about a certain political statement. Secondly, Kripke structures come with a number of very powerful and well studied query languages, namely modal logics (1). In our case, multi-modal logics seem to be the obvious choice for querying multi-relation structures. They extend propositional logic by adding a family of modal operators $\{\Diamond_1, \ldots, \Diamond_d\}$. Formally, let $\mathsf{PROP} = \{p, q, \ldots\}$ be a set of propositional variables. The syntax of multi-modal logic MML is as usual: $\varphi := \top \mid p \mid \neg\varphi \mid \varphi \wedge \psi \mid \Diamond_i$. To simplify matters, $\varphi \vee \psi$ and $\Box_i\varphi$ are defined as abbreviations for $\neg(\neg\varphi \wedge \neg\psi)$ and $\neg\Diamond_i\neg\varphi$. Let $\mathcal{K}$ be a Kripke structure and $m \in M$. The semantics of multi-modal logic is defined as usual:

$$
\begin{array}{lll}
\mathcal{K}, m \models \top & & \\
\mathcal{K}, m \models p & \text{iff} & m \in V(p),\, p \in \mathsf{PROP} \\
\mathcal{K}, m \models \neg\varphi & \text{iff} & \mathcal{K}, m \not\models \varphi \\
\mathcal{K}, m \models \varphi \wedge \psi & \text{iff} & \mathcal{K}, m \models \varphi \text{ and } \mathcal{K}, m \models \psi \\
\mathcal{K}, m \models \Diamond_i\varphi & \text{iff} & \exists m' \, (R_i m m' \wedge \mathcal{K}, m' \models \varphi)
\end{array}
$$

To see the potential of modal logic as a query language, let us study an example: *give me politicians criticising other politicians?* Asking this query over the Kripke structure $\mathcal{K}_{ex}$ should return the name Timmermans, because ⟨`Timmermans`,–, `Melkert`⟩$\in NET_{ex}$, as well as Melkert:PolActor$\in \mathcal{O}_{ex}$ and Timmermans:PolActor$\in \mathcal{O}_{ex}$. Formally, the set of answers to this query is the set of all worlds n for which $\mathcal{K}_{ex}, n \models$PolActor$\wedge\Diamond_{-}$PolActor, where $\Diamond_{-}$ is interpreted as the relation –. More generally, given any Kripke structure $\mathcal{K}$, and an arbitrary formula φ in the basic language, it is well known that it can be checked in linear time whether φ is true at a state in $\mathcal{K}$ or not.

Unfortunately, the logic is not yet expressive enough for some important queries which are needed in our case study. First, we are unable to ask for adversaries of particular political actors, or opinions of politicians with respect to specific political issues. This is because modal logics usually do not allow to address worlds by their names, i.e. they usually don't have support for nominals. So, if we were to ask about those politicians opposing immigration, we would need the name of the issue immigration in our language. Then the query (Politician$\wedge\Diamond_{-}$immigration) would capture our intuition.

But we need even more. A type of query that is required for the political investigations are about internal disagreement, that also cannot be expressed, even with nominals. In the following example we want to query for a political party, which has suffered criticism on a particular issue it supports from one of its members. Basically the query should include the proposition Party, i.e. we search for a party, and an issue this party supports, i.e. $\Diamond_m \Diamond_+ \mathsf{Issue}$. Finally, we need to find a member of the party, which is critical of the same issue. But here we fail, as we cannot state equality of two issues or two parties, respectively. What is needed is a further extension of our logic with weak quantification, or variable binding.

3.4 Hybrid Logics

Hybrid Logic (HL, for short) extends multi-modal logic with devices for naming states and accessing states by names. Let $\mathsf{NOM} = \{i, j, \ldots\}$ and $\mathsf{WVAR} = \{x, y, \ldots\}$ be sets of nominals and state variables, respectively. HL's syntax is: $\varphi := \text{MML} \mid i \mid x \mid @_t \varphi \mid \downarrow x.\varphi \mid \exists x.\varphi$, with $i \in \mathsf{NOM}$, $x \in \mathsf{WVAR}$, $t \in \mathsf{NOM} \cup \mathsf{WVAR}$. The operators in $\{@, \downarrow, \exists\}$ are called *hybrid operators*. We call $\mathsf{WSYM} = \mathsf{NOM} \cup \mathsf{WVAR}$ the set of *state symbols*, and $\mathsf{ATOM} = \mathsf{PROP} \cup \mathsf{NOM} \cup \mathsf{WVAR}$ the set of *atoms*. For simplicity, we omit parenthesis after the $\downarrow$. For instance, $\downarrow x.p \wedge @_x q$ should be read as $\downarrow x.(p \wedge @_x q)$.

Hybrid Logic is interpreted over *hybrid Kripke structures*, i.e., Kripke structures $\langle M, R, V \rangle$ where the valuation function V assigns singleton subsets of M to nominals $i \in \mathsf{NOM}$. To give meaning to the formulas, we also need the notion of *assignment*. An assignment g is a mapping $g : \mathsf{WVAR} \to M$. Given an assignment g, we define g^x_m by $g^x_m(x) = m$ and $g^x_m(y) = g(y)$ for $x \neq y$. For any atom a, let $[V, g](a) = \{g(a)\}$ if a is a state variable, and $V(a)$ otherwise.

The semantics of hybrid logic is defined over a hybrid Kripke structure $\mathcal{K} = \langle M, R, V \rangle$, where $m \in M$, and g is an assignment; the semantics for Boolean and modal operators is as before.

$\mathcal{K}, g, m \models a$	iff	$m \in [V, g](a)$, $a \in \mathsf{ATOM}$
$\mathcal{K}, g, m \models @_t \varphi$	iff	$\mathcal{K}, g, m' \models \varphi$, where $[V, g](t) = \{m'\}$, $t \in \mathsf{WSYM}$
$\mathcal{K}, g, m \models \downarrow x.\varphi$	iff	$\mathcal{K}, g^x_m, m \models \varphi$
$\mathcal{K}, g, m \models \exists x.\varphi$	iff	there is $m' \in M$ such that $\mathcal{K}, g^x_{m'}, m \models \varphi$

This means that $@_t$ shifts evaluation to the state named by t, where t is a nominal or a variable. The down-arrow $\downarrow x$ binds the state variable x to the *current* state, while the existential binder $\exists x$ binds to *some* state in the model; $\downarrow$ and $\exists$ do not shift evaluation away from the current state. The definition of hybrid logic is almost literally taken from (7). We also refer to (2) for an introduction to hybrid logics.

By adding one or more of these hybrid operators to our modal language, we can obtain a number of hybrid logics, such as $H(@)$ and $H(@, \downarrow)$, with different expressivity and computational complexity. Which of these logics is needed depends on the specific query to be formulated.

For example, to know if any politician is taking a negative issue position, simple modal logic suffices: $\mathsf{Politician}\Diamond_{-}\mathsf{Issue}$. If we also want to know which politician is taking this position, we need to interpret the hybrid structure, as we want to bind to a specific world rather than the whole Kripke structure, and thus arrive in $H(@)$, the least expressive hybrid logic.

If we want to formulate *internal disagreement*, we also need the $\downarrow$ binder to be able to require two accessibility 'branches' to reach the same state: $\downarrow x.\mathsf{Party} \wedge (\Diamond_m \Diamond_+ (\mathsf{Issue} \wedge \downarrow y.(@_x \Diamond_m \Diamond_- y)))$. The outer binder binds the current state, i.e. the party we query for, to a variable. Inside the formula, we then enforce a criticism relation between a party member and the issue in question.

Hybrid Logics as query languages over Kripke structures stemming from NET graphs with background knowledge offer sufficient expressiveness to emulate realistic investigations in content analysis. Moreover, as there is a fully-fledged model checker publicly available, these results almost come for free, as we will show in the following section.

4 Experiments and results

The experimental validation of our proposed method is a secondary analysis based on articles coded for the investigation of the Dutch 2002 parliamentary campaign by (9). This data set consists of 7,478 newspaper articles and television items from 20 November 2001 to 14 May 2002 of which the headline and leading paragraph were coded, yielding 35,031 triples.

Each article was translated into a Kripke structure as described in 3.2, using a background ontology formlaising party membership of all politicians. Finally, propositions were added that identify politicians, parties, political actors (comprising politicians and parties), and issues. We then formalised the main political concepts as modal or hybrid logic formulas. Using the model checker described in (6, see also 7), these formal HL queries were then checked in each of these Kripke structures, resulting in a list of parties, politicians or issues for which these formulas were true.

These outcomes were summarised per period and compared to the results presented in the original study. Small discrepancies occur because in the original study the number of edges were counted rather than the number of worlds. In fact the difference occurs because the way we pose our queries: we search for an issue that is disputed by politicians, and not for politicians disputing an issue.

Horserace news:	$\mathsf{reality} \wedge (\Diamond_{+}\mathsf{PolActor} \vee \Diamond_{-}\mathsf{PolActor})$
Conflict news:	$\mathsf{Actor} \wedge (\Diamond_{+}\mathsf{PolActor} \vee \Diamond_{-}\mathsf{PolActor})$
Issue news:	$\mathsf{PolActor} \wedge (\Diamond_{+}\mathsf{Issue} \vee \Diamond_{-}\mathsf{Issue})$

Concept	until interview	until loc. elections	until murder	after murder	total	n	*Orig.*
Conflict	40%	44%	46%	57%	45%	4,613	*49%*
Horserace	14%	13%	19%	24%	17%	1,721	*20%*
Issue	47%	42%	35%	19%	39%	3,968	*31%*

Table 1
Relative attention to news types

4.1 Modal logic: General political frames

To measure the general tone of the campaign news, three modal logic queries were used to discover the three general news frames [2] used for the original study. Table 1 shows the relative attention for these frames, i.e. the number of Kripke structures in which there was a world in which the corresponding formula was true. The total percentages are compared to the percentages published in (9, table 2.2), which we restate in the last column of the table for convenience.

4.2 $H(@)$: Issue positions of politicians and parties

To discover the average position of politicians on one of the key issues, immigration, two $H(@)$ queries were used. Note that this requires interpreting the hybrid Kripke structures as we want to know the names of the worlds (i.e. politicians) in which the formula holds [3]. Table 2 reports the average direction of the position on immigration per party per period, i.e. $(anti - pro)/(anti + pro)$, compared to table 4.3 from (9).

Interesting to see is the tempering of Fortuyn's position in the period between the local elections and his assassination, also reported in figure 4.1 of the original study. Note also the 'jerk to the right' by both incumbent parties (VVD and PvdA) after the interview while the CDA actually becomes more positive about immigration.

4.3 $H(@, \downarrow)$ with background knowledge: Internal dissent

To discover different forms of internal strife, three $H(@, \downarrow)$ formulas were used on the combined media-data and background knowledge. In these formulas

[2] In communication science, *framing* indicates the way an actor or issue is depicted (or *framed*) in the news.
[3] Note that to bind to the parties rather than the politicians, we would have to use the inverse membership relation , defined as $\Diamond_i^{inv}\varphi \equiv \exists x.(\Diamond_i x \wedge \varphi)$, which requires $H(@, \downarrow)$

Pro-immigration: $\mathsf{PolActor} \wedge \Diamond_{+}\mathsf{immigration}$
Anti-immigration: $\mathsf{PolActor} \wedge \Diamond_{-}\mathsf{immigration}$

Party	until interview	until loc. elections	until elections	total	(n)	*Original*
VVD	-0.42	-0.50	-0.76	-0.53	(60)	*-0.66*
PvdA	0.29	-0.45	-0.11	-0.07	(97)	*-0.11*
CDA	-0.71	-0.56	0.00	-0.57	(41)	*-0.66*
Fortuyn	-1.00	-1.00	-0.48	-0.62	(104)	*-0.52*

Table 2
Average position on immigration

$\Diamond_m$ represents the memberOf relation between a party and a person. Table 3 gives the total number of occurrences of these three frames, as summarised in figure 5.1 from (9), the *support−criticism* per week is also given and compared to the original number. The difference in scale is a result of the counting of nodes (parties) rather than edges as explained above. An interesting result is that no party seems to be able to have internal discussion without internal (personal) criticism, although the PvdA shows in the last period that the internal discussion need not keep step with the criticism.

Internal criticism: $\downarrow x.\mathsf{Party} \wedge (\Diamond_m^{inv}\Diamond_{-}(x \vee \Diamond_m x) \vee \Diamond_{-}(x \vee \Diamond_m x))$
Internal support: $\downarrow x.\mathsf{Party} \wedge (\Diamond_m^{inv}\Diamond_{+}(x \vee \Diamond_m x) \vee \Diamond_{+}(x \vee \Diamond_m x))$
Internal disagreement: $\downarrow x.\mathsf{Party} \wedge (\Diamond_m\Diamond_{+}(\mathsf{Issue} \wedge \downarrow y.(@_x\Diamond_m\Diamond_{-}y)))$

Party	until interview					until elections					until murder				
	disa	crit	supp	diff	*orig*	disa	crit	supp	diff	*orig*	disa	crit	supp	diff	*orig*
PvdA	59	64	42	-1.9	*-3*	9	12	14	0.6	*1*	46	110	76	-4.0	*-8*
VVD	39	55	66	1.0	*3*	11	6	16	2.8	*5*	55	66	70	0.5	*6*
CDA	7	6	7	0.1	*0*	0	8	15	2.0	*4*	5	7	9	0.2	*0*
LPF	3	1	3	0.2	*0*	7	4	11	2.0	*4*	34	28	40	1.4	*1*

Table 3
Internal Criticism and Debate

5 Conclusion

In this paper we describe first attempts at using modal logics, with their well studied formalisms and tools in media studies. As a proof of concept, we reproduce relevant results of a case study about the Dutch election campaign of 2002. We do this by formalising newspaper articles as Kripke structures, and by using an existing hybrid model checker to search for instances of politically interesting patterns. This approach has some nice properties: we can use an existing logic with well-studied semantics and out-of-the-box tools. We can do this, because of the close relation of the social scientist's intermediate NET representation with Kripke structures. As a result, we can offer explicit formal semantics, easy integration of background knowledge, and an expressive query language, as well as, with the hybrid model checker, a generic tool for querying.

5.1 Relevance to Communication Science

Using this method has three advantages to communication sciences. First, it allows for an easy way to formally describe the concepts used in a study. This can make a study more transparent and hence more repeatable.

Second, by making the investigated concepts and domain knowledge formal and explicit, the amount of specific code or SPSS syntax that has to be written to conduct an analysis is greatly reduced. In fact, apart from the general code to translate NET articles to Kripke structures and to invoke the model checker on those structures with the queries, no code or syntax was written at all for this study.

Finally, it allows the separation of the domain specific knowledge (in the ontology) from the definition of the concepts/frames. This makes it possible to define and maintain the domain ontology without knowing the specific queries that will be asked and, more importantly, to formulate the concepts in general enough terms to compare concepts in different domains. The current queries could also be used on the Dutch election campaigns of 1994 and 1998 or even the American presidential campaigns.

Of course, whether the findings of one study, or even the concepts used in those findings, are useful in different circumstances is another question, one that is crucial for many studies: How far can the proposed concepts and theories be generalised? The method described here can be a tool to help investigate such questions, thus allowing for more systematic meta-research and theory-building.

5.2 Shortcomings, limitations and challenges

Obviously, the streamlining of the analysis process into this particular modal logic formalism comes at a price. The reduction of querying NET graphs with background knowledge from complex reasoning to model checking is only possible because of two relatively strong assumptions: first, we assume complete knowledge about the actors and issues (at least w.r.t. the propositions in our domain), and we restrict our background knowledge to very simple "unfoldable" axioms. There has recently been a surge in interest in simple terminologies to reduce the complexity of reasoning (for example (4)), and we would claim that it should be reasonably simple to extend our approach to more expressive ontologies.

To simplify this presentation, we did not combine the semantics of the NET relations into the modal reasoning, such as transitivity or combination of arrows. Instead we applied explicit constraint propagation before translating to Kripke structures. This, however, is somehow inconsistent with our unifying approach taken otherwise. Another limitation is our failure to capture the quantitative aspects of NET representations. In part, we avoid the issue by considering individual documents rather than aggregated NET graphs. Thus, the statistical variance is expressed in the results of the analysis, rather than explicitly in the representation itself. Nevertheless, a certain level of approximation and fuzziness is lost in the process.

Another strong restriction of our current approach is the lack of any temporal or epistemic dimension: queries for *changes of mind over time* or *reactions on someone*, let alone *differences between newspapers* cannot be expressed. Nevertheless, we take this shortcoming as a challenge for future work, rather than a limitation, as there is extensive work on multi-dimensional modal logics to start with (just to mention (8)).

References

[1] Blackburn, P., M. de Rijke and Y. Venema, "Modal Logic," Cambridge University Press, 2001.

[2] Blackburn, P. and J. Seligman, *What are hybrid languages?*, Advances in Modal Logic **1**, CSLI Publications, Stanford University, 1998 pp. 41–62.

[3] Bryant, J. and D. Zillman, editors, "Media Effects: Advances in Theory and Research," Lawrence Erlbaum, Mahwah, NJ, 2002.

[4] Calvanese, D., G. De Giacomo, D. Lembo, M. Lenzerini and R. Rosati, *Dl-lite: Tractable description logics for ontologies*, in: *Proc. of the 20th Nat. Conf. on Artificial Intelligence (AAAI 2005)*, 2005.

[5] Carley, K., *Content analysis*, in: R. Asher, editor, *The Encyclopedia of Language and Linguistics*, Pergamon, Edinburgh, 1990 .

[6] Dragone, L., *Hybrid logics model checker*, C implementation published on http://www.luigidragone.com/hlmc/ (2005-07-06) (2005).

[7] Franceschet, M. and M. de Rijke, *Model checking for hybrid logics (with an application to semistructured data)*, Journal of Applied Logic (2005).

[8] Gabbay, D. M., A. Kurucz, F. Wolter and M. Zakharyaschev, "Many-Dimensional Modal Logics: Theory and Applications," Elsevier, 2003.

[9] Kleinnijenhuis, J., D. Oegema, J. de Ridder, A. van Hoof and R. Vliegenthart, "De puinopen in het nieuws," Communicatie Dossier **22**, Kluwer, Alpen aan de Rijn (Netherlands), 2003.

[10] Krippendorff, K., "Content Analysis: An Introduction to Its Methodology (second edition)," Sage Publications, 2004.

[11] McCombs, M. E. and D. L. Shaw, *The agenda-setting function of mass media*, Public Opinion Quarterly **36** (1972), pp. 176–187.

[12] Roberts, C., editor, "Text Analysis for the Social Sciences; Methods for

Drawing Statistical Inferences from Texts and Transcripts," Lawrence Erlbaum Associate, Mahwah, New Jersey, 1997.

[13] Van Atteveldt, W., N. Ruigrok and J. Kleinnijenhuis, *Associative framing: A unified method for measuring media frames and the media agenda*, in: *Submitted to the 56th Annual Conference of the International Communication Association (ICA2006), Dresden, Germany (June 19 – 23, 2006)*, forthcoming.

[14] Wiebe, J., T. Wilson, R. Bruce, M. Bell and M. Martin, *Learning subjective language*, Computational Linguistics **30 (3)** (2004).

[15] *Wikipedia, the free encyclopedia*, URL://www.wikipedia.org (2005).