A comparison between AMR, MRS and DRS

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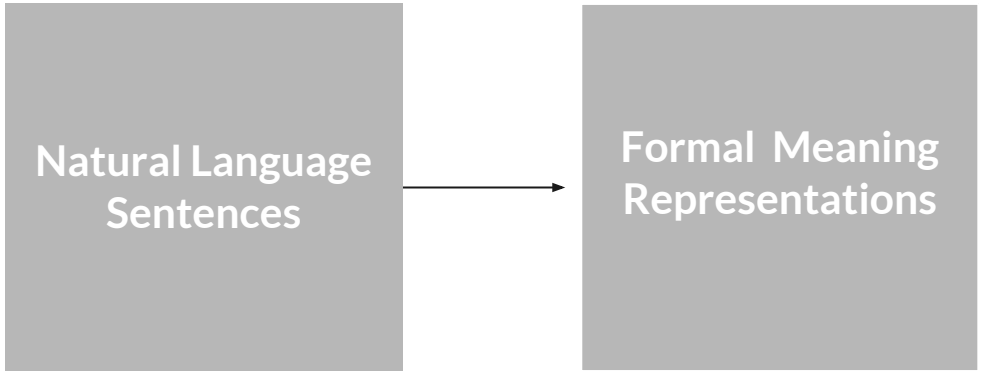
Three different meaning representations.



A brief introduction to MRS

- Minimal Recursion Semantics (MRS) is a framework for computational semantics that can be used for parsing and generation.
- Instances and eventualities are represented with logical variables.
- The underlying assumption behind MRS is that the primary units of interest for computational semantics are *elementary predications* or EPs. EPs are single relation with its associated arguments.
- For instance: *a little cat* EPs: little(x), cat(x)

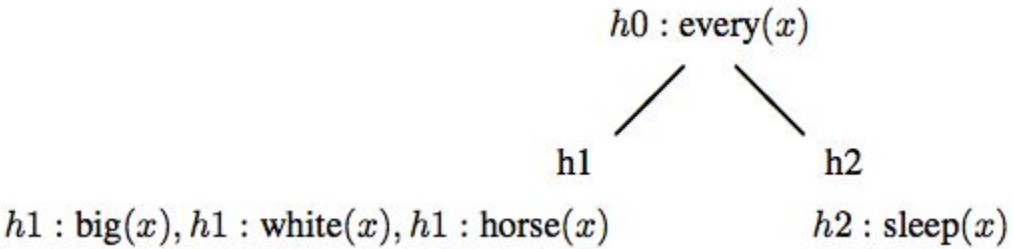
A brief introduction to MRS

- MRS is a syntactically ‘flat’ representation, since the EPs are never embedded within one another.
- For instance: *Every big white horse sleeps.*

  non-MRS: every(x, ⋀(big(x), ⋀(white(x),horse(x))),sleep(x))

  MRS: every(x, ⋀(big(x), white(x), horse(x)), sleep(x))

- Handles



A brief introduction to DRS

- Discourse Representation Structure (DRS) is the meaning structure in Discourse Representation Theory (DRT), which is a framework for representing the meaning of sentences and discourse.
- DRS consists of referents and conditions. Referents are the entities in the discourse. Conditions represent the information about the referents.

A brief introduction to DRS

- There are 6 different referents in DRS, they are common referents (x), event referents (e), state referents (s), segment referents (k), proposition referents (p) and time referents (t).
- For example, *A boy goes*.
  go(e1), boy(x1)

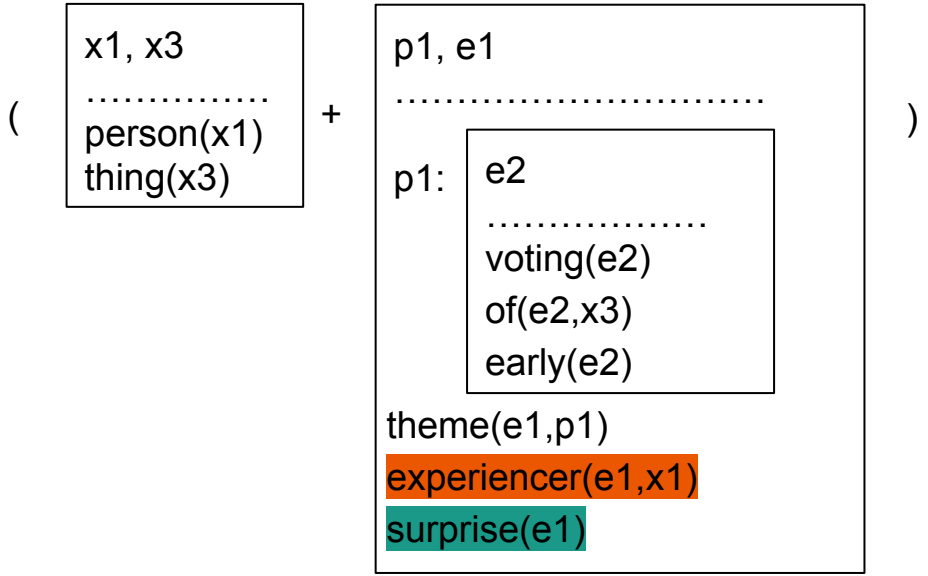
- There are basic conditions and complex conditions in DRS. Basic conditions represent the properties of referents or the relations between them.
- Fow example, Agent(e1, x1), Theme(e1, x2)

- Complex conditions represent the relation of DRSs, in other words, complex conditions take DRSs as arguments.

Their voting early surprised me.

```
(s / surprise-01
        :ARG1 (i / i)
        :ARG0 (b / be-temporally-at-91
                :ARG1 (v / vote-01
                        :ARG0 (t / they))
                        :ARG2 (e / early)))
```

AMR



DRS

Their voting early surprised me.

MRS

⟨*h*1,
*h*4: def_explicit_q(ARG0 *x*6, RSTR *h*7, BODY *h*5),
*h*8: poss(ARG0 *e*10, ARG1 *x*6, ARG2 *x*9),
*h*11: pronoun_q(ARG0 *x*9, RSTR *h*12, BODY *h*13),
*h*14: pron(ARG0 *x*9),
*h*8: nominalization(ARG0 *x*6, ARG1 *h*15),
*h*15: _vote_v_1(ARG0 *e*16, ARG1 *x*9),
*h*15: loc_nonsp(ARG0 *e*17, ARG1 *e*16, ARG2 *x*18),
*h*19: time_n(ARG0 *x*18),
*h*20: def_implicit_q(ARG0 *x*18, RSTR *h*21, BODY *h*22),
*h*19: _early_a_1(ARG0 *e*23, ARG1 *x*18),
*h*2: _surprise_v_1(ARG0 *e*3, ARG1 *x*6, ARG2 *x*24),
*h*25: pron(ARG0 *x*24),
*h*26: pronoun_q(ARG0 *x*24, RSTR *h*27, BODY *h*28)
{*h*27 =q *h*25,*h*21 =q *h*19,*h*12 =q *h*14,*h*7 =q *h*8,*h*1 =q *h*2}⟩

Three different meaning representations.

- We define a common framework for **semantic graphs** in which we can place AMR, MRS and DRS.
- Sentence meaning is represented with rooted, labelled, connected, directed graphs.

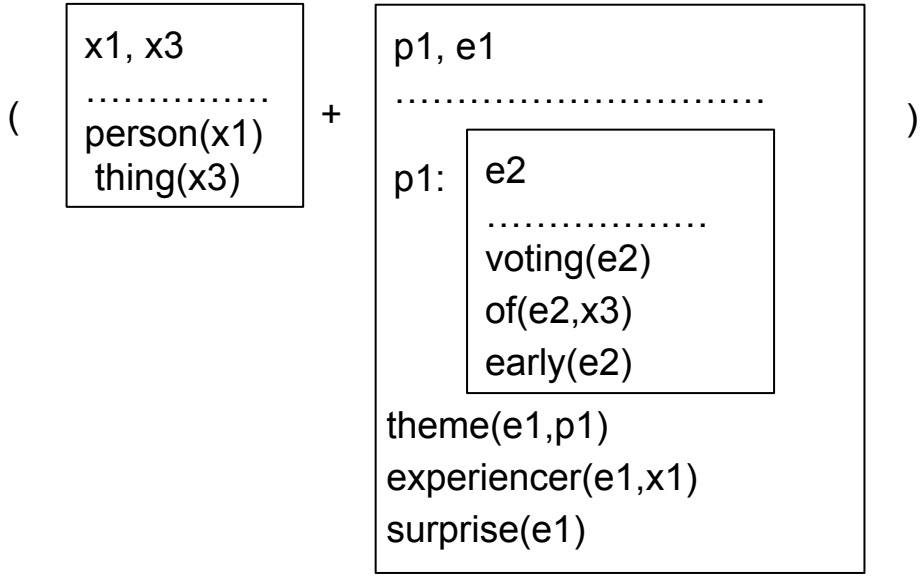
Their voting early surprised me.

⟨*h*1,
*h*4: def_explicit_q(ARG0 *x*6, RSTR *h*7, BODY *h*5),
*h*8: poss(ARG0 *e*10, ARG1 *x*6, ARG2 *x*9),
*h*11: pronoun_q(ARG0 *x*9, RSTR *h*12, BODY *h*13),
*h*14: pron(ARG0 *x*9),
*h*8: nominalization(ARG0 *x*6, ARG1 *h*15),
*h*15: _vote_v_1(ARG0 *e*16, ARG1 *x*9),
*h*15: loc_nonsp(ARG0 *e*17, ARG1 *e*16, ARG2 *x*18),
*h*19: time_n(ARG0 *x*18),
*h*20: def_implicit_q(ARG0 *x*18, RSTR *h*21, BODY *h*22),
*h*19: _early_a_1(ARG0 *e*23, ARG1 *x*18),
*h*2: _surprise_v_1(ARG0 *e*3, ARG1 *x*6, ARG2 *x*24),
*h*25: pron(ARG0 *x*24),
*h*26: pronoun_q(ARG0 *x*24, RSTR *h*27, BODY *h*28)
{*h*27 =q *h*25,*h*21 =q *h*19,*h*12 =q *h*14,*h*7 =q *h*8,*h*1 =q *h*2}⟩

MRS

```
(s / _surprise_v_1
      :ARG1 (n / nominalization
            :ARG1-of (p / poss
                  :ARG2 (p2 / pron))
            :ARG1 (v / _vote_v_1
                  :ARG1 p2
                  :ARG2 (t / time_n
                        :ARG1-of (e / _early_a_1))))
      :ARG2 (p3 / pron))
```

Their voting early surprised me.

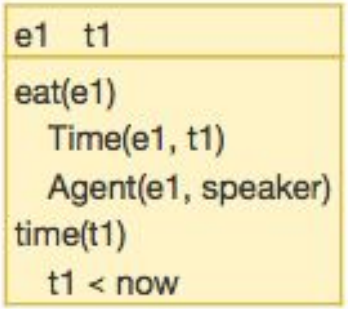



```
(e1 / surprise
        :experiencer (x1 / person)
        :theme (e2 / voting
                :edge (e2 / early)
                :of (x3 / thing)))
```

DRS

Three different formats of DRS

I ate.



Box Format

```
                          % I [0...1]
b1 REF e1                 % ate [2...5]
b1 Agent e1 "speaker"     % ate [2...5]
b1 Time e1 t1             % ate [2...5]
b1 eat "v.02" e1          % ate [2...5]
b2 REF t1                 % ate [2...5]
b2 TPR t1 "now"           % ate [2...5]
b2 time "n.08" t1         % ate [2...5]
                          % . [5...6]
```

Clause Format

It is not clear if they made that decision based on a request from Mr. Abdullah.

DRS(IMP(DRS(THING(X1) decision(X2) EQ(X2 X3) base(E1) THEME(E1 X3) request(X4) mr.(X5) EQ(X6 X5) abdullah(X6) from(X4 X6) on(E1 X4) make(E2) ASSET(E2 X1) PRODUCT(E2 X2)) DRS(THING(X1) NOT(DRS(clear(S1) LOCATION(S1 X1)))))))

Tree Format

Their voting early surprised me.

```
(s / surprise-01
      :ARG1 (i / i)
      :ARG0 (b / be-temporally-at-91
            :ARG1 (v / vote-01
                  :ARG0 (t / they))
                  :ARG2 (e / early)))
```

AMR

```
(e1 / surprise
      :experiencer (x1 / person)
      :theme (e2 / voting
            :edge(e2 / early)
            :of (x3 / thing)))
```

DRS

```
(s / _surprise_v_1
   :ARG1 (n / nominalization
         :ARG1-of (p / poss
               :ARG2 (p2 / pron))
         :ARG1 (v / _vote_v_1
               :ARG1 p2
               :ARG2 (t / time_n
                     :ARG1-of (e / _early_a_1))))
   :ARG2 (p3 / pron))
```

MRS

1. Predicate, Role and Semantic Relation

- Predicates senses and core semantic roles in AMR are drawn from OntoNotes project.
- The graph nodes in AMR denote the predicate and the role
- The edge refers to the semantic relations between the predicate and the role.

```
(s / surprise-01
      :ARG1 (i / i)
      :ARG0 (b / be-temporally-at-91
            :ARG1 (v / vote-01
                  :ARG0 (t / they))
                  :ARG2 (e / early)))
```

1. Predicate, Role and Semantic Relation

- The graph nodes in AMR denote the predicate and the role
- The edge refers to the semantic relations between the predicate and the role.
- Core roles are taken from the OntoNotes semantic role layer.
- In addition to core roles, AMR annotates non-core role with relation as semantic adjuncts, which are not selected by the predicate and do not play unique roles with regard to a particular predicate, including beneficiary, condition, degree, destination, manner, time, etc.
- The predicate is sense-disambiguated following the definition in PropBank.

```
(s / surprise-01
    :ARG1 (i / i)
    :ARG0 (b / be-temporally-at-91
        :ARG1 (v / vote-01
            :ARG0 (t / they))
            :ARG2 (e / early)))
```

1. Predicate, Role and Semantic Relation

- The hand-built ERG lexicon of some 39,000 lemmata, instantiating 975 leaf lexical types providing part-of-speech and valence constraints, aims for complete coverage of function words and open-class words with ‘non-standard’ syntactic properties.
- MRS makes an explicit distinction between surface and abstract predicates. Surface predicates consist of a lemma followed by a coarse part-of-speech tag and an optional sense label.

- _look_v_up: Researchers can drive by hours, **look up** credit ratings, and even question neighbors.
- _look_v_like: It **looks like** a holiday.
- _look_v_1: **Look** how much air is moving around!

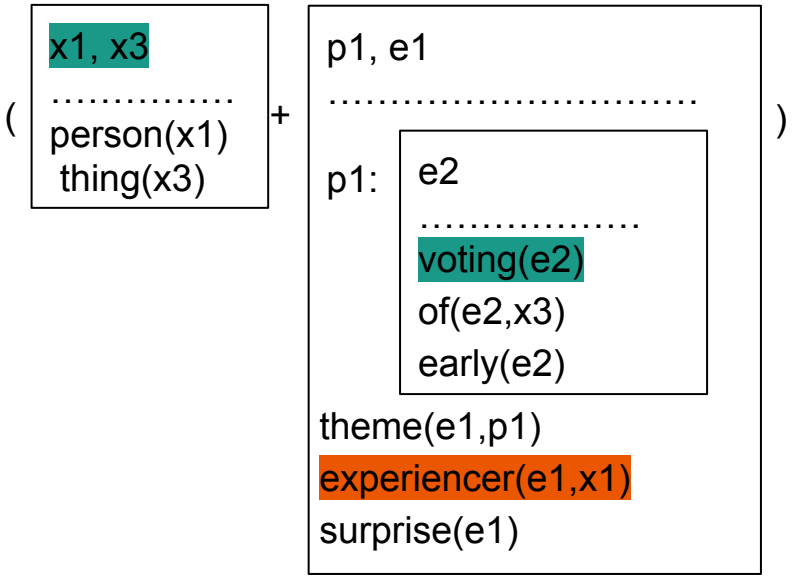
1. Predicate, Role and Semantic Relation

- Predicate absent from the ERG lexicon are represented by their surface forms and POS tags.
- In MRS, predicates take arguments with labels from a small, fixed set of roles.
- Arguments are either logical variables or handles.

- _buckshot/nn_u_unknown: The Bush administration ought to be setting aside some of the its buckshot for the non-duck ducks.
- *h*8: nominalization(ARG0 *x*6, ARG1 *h*15),

1. Predicate, Role and Semantic Relation

- In DRS, referents are listed on the top of the box, one place predicates tell us the which word this referent is referring to, two-place predicate usually tell us the relations between referents.



1. Predicate, Role and Semantic Relation

- DRS uses self-defined predicates and arguments.
  Some examples are:
  Agent(e, x),Theme(e, x), Product(e, x), Goal(e, p), etc.

- Some specific projects using DRS as their semantic representation might take advantage of extant linguistic resource to do word sense disambiguation. For example, Parallel Meaning Bank introduces WordNet senses and VerbNet roles.

(e1 / surprise
:experiencer (x1 / person)
:theme (e2 / voting
:edge(e2 / early)
:of (x3 / thing)))

```
b1 REF e1                % Think [0...5]
b1 Agent e1 "hearer"     % Think [0...5]
b1 think "v.03" e1       % Think [0...5]
b1 Theme e1 x1           % about [6...11]
b2 REF x1                % it [12...14]
b2 entity "n.01" x1      % it [12...14]
                         % . [14...15]
```

2. Name-entity

- AMR borrows name entities from information extraction and question answering. Some of the name entities in AMR are:
- person, family, animal
- organization, company, school
- location, city
- ……

2. Name-entity for MRS

- MRS has buit-in support for light-weight named entity recognition using named-relation.
- This type is used for proper names, and it introduces a feature *carg* (‘constant argument’) which takes as its value a string representing the name of the named entity.
- For example, *Goldman, Sachs & Co. and Montgomery Securities Inc*.

```
(X5 / _and_c
      :L-INDEX (X10 / named
            :carg “Sachs”
            :ARG1-of (i24 / compound
                  :ARG2 (x20 / _and+compony_n_1))
            :ARG1-of (e14 / compound
                  :ARG2 (x13 / named
                        :carg “Goldman”)))
      R-INDEX (x26 / named
            :carg “Securities”
            :ARG1-of (i42 / compound
                  :ARG2 (x38 / _inc_n_1))
            :ARG1-of (e32 / compound
                  :ARG2 (x31 / named
                        :carg “Montgomery”))))
```

2. Name-entity

- Name-entities are annotated with one place predicates in DRS.
  For example, MALE(x1)

- Here is a (partial) list of the name-entity in DRS: PERSON, MALE, FEMALE, DOLLAR, AMOUNT, MANNER, EVENT, THING, LOCATION

3. Date-entity

Date-entity	Example	AMR	MRS
calendar	lunar calendar	`:calendar (m / moon)`	–
era	AD	`:era "AD"`	–
century	20th century	`:century 20`	`_century_n_1` `:ARG1-of(e69 / ord :carg "20th")`
decade	1950s	`:decade 1950`	`year_range :carg "1950s"`
year	2001	`:year 2001`	`yofc :carg "2001"`
season	winter	`:season (w / winter)`	`season :carg "winter"`
quarter	fourth quarter	`:quarter 4`	`_quarter_n_temp` `:ARG1-of (e41 / ord :carg "4")`
month	December (8th)	`:month 12`	`mofy :carg "Dec"`
weekday	Monday	`:weekday (m / monday)`	`dofw :carg "Mon"`
day	(December) 8th	`:day 8`	`dofm :carg "8"`
dayperiod	night	`:dayperiod (n / night)`	–
timezone	GMT (6:00)	`:timezone "GMT"`	–
time	(GMT) 6:00	`:time "6:00"`	`numbered_hour :carg "6:00"`

3. Date-entity

- DRS doesn’t pay much attention to define date-entity. There are two cases in DRS that date information is represented differently. They are year and day.
- *In 2018* will be denoted as TIMEX(x_i, TIME_NUMBER), where TIMEX expresses temporal information, TIME_NUMBER means the number of the year.
- The second case is day information, for example *March 8th* is represented as TIMEX(x_i, TIME_NUMBER).

Text	Annotation
In 2018	TIMEX(x, TIME_NUMBER)
March 8th	TIMEX(x, TIME_NUMBER)
Century	century (x)

4. Conjunction

- To represent conjunction, AMR uses concepts:

- and: The boy and the girl - :op1 (b / boy) :op2 (g / girl)
- contrast-01: There was shouting, but the boy stayed. / But the boy stayed.
- either: Either the boy, the girl, or the dog.
- neither:

4. Conjunction

- MRS provides two relation types for subordination and coordination, both subtypes of *subord-or-conj-relation*, which introduces two new attributes for their semantic arguments.
- The first subtype *subord-relation* can be used for subordinating conjunctions like English *since*.
- The second subtype *conjunction-relation* is used by ordinary conjunctions like English *and*.

- For example, *Goldman, Sachs & Co. and Montgomery Securities Inc*.

```
(X5 / _and_c
      :L-INDEX (X10 / named
            :carg “Sachs'”
            :ARG1-of (i24 / compound
                  :ARG2 (x20 / _and+compony_n_1))
            :ARG1-of (e14 / compound
                  :ARG2 (x13 / named
                        :carg “Goldman”)))
      :R-INDEX (x26 / named
            :carg “Securities”
            :ARG1-of (i42 / compound
                  :ARG2 (x38 / _inc_n_1))
            :ARG1-of (e32 / compound
                  :ARG2 (x31 / named
                        :carg “Montgomery”))))
```

4. Conjunction

- DRS uses a unique predicate to represent conjunction: SUBSET_OF
- For example, *a cat and a dog* is represented with cat(x1), dog(x2), SUBSET_OF(x1, **x3**), SUBSET_OF(x2, **x3**).
- Think of ‘a cat and a dog’ as a set, then ‘cat’ and ‘dog’ are it’s two subsets.

- DRS also has conjunction between discourse referents.
  For example, suppose we have 2 discourse referents k1, k2 connected with *and.*
  DRS uses CONTINUATION(k1, k2), PARALLEL(k1, k2) to represent this conjunction.

5. Negation

- AMR represents negation logically, using :polarity
- For example, *The boy doesn't go*

```
(g / go-02
      :ARG0 (b / boy)
      :polarity -)
```

5. Negation

- In MRS, the negation is represented as node with scope, for example,

  I don't see any signs that inventories are excessive.

```
(e10 / neg
        :ARG1 (e3 / _see_v_1
                :ARG1 (x5 / pron)
                :ARG2 (x12 / _sign_n_of
                        :ARG2-of (e24 / _be_v_id
                                :ARG1 (x20 / _inventory_n_1)
                                :ARG1-of (e27 / subord
                                        :ARG2 (e30 / _excessive_a_1)))
                        :BV-of (_2 / _any_q))))
```

5. Negation

- In DRS, negation is represented on a discourse level, negation in DRS comes with a scope.
- In particular, negation is represented with a **complex condition**, NOT DRS.
- Negation is defined as following:
- B NOT B’: DRS B contains DRS-condition ¬ B' (it is not the case that)

5. Negation

- *Some hard-liners fear they will not be properly represented in the Fatah list .*

DRS(hard-liner(X1) fear(E1) EXPERIENCER(E1 X1) STIMULUS(E1 P1) P1(DRS(THING(X2) NOT(DRS(NEC(DRS(represent(E2) THEME(E2 X2) fatah(X3) OF(X4 X3) list(X4) in(E2 X4) properly(E2))))))))

- B NOT B': DRS B contains DRS-condition ¬ B'
- Let negation follow the **event referent** in that DRS.

```
(E1 / fear
        :EXPERIENCER (X1 / hard-liner)
        :STIMULUS (E2 / represent
                :EDGE (E2 / properly)
                :polarity -
                :arg1-of NEC
                :THEME (X2 / THING)
                :in (X4 / list
                        :OF (X3 / fatah))))
```

6. Modality

- AMR represents syntactic modals with concepts like possible-01, likely-01, obligate-01, permit-01, recommend-01, prefer-01, etc.

- *The boy can go.*

  (p / possible-01
  :ARG1 (g / go-02)
  :ARG0 (b / boy))

6. Modality

- MRS uses *_modal* to indicate the modality in the sentence.
- However, modality in MRS is word-specified, for example, in AMR, the sentences *It may rain* and *It might rain* all refer to the concept possible-01, while in MRS, they are different concepts -- *_may_v_modal* and *_might_v_modal*.
- For example, *Political and currency gyrations can whipsaw the funds.*

```
(e3 / _can_v_modal
        :ARG1 (e25 / "_whipsaw/vb_u_unknown"
                :ARG1 (x6 / _gyration_n_1
                        :ARG1-of (e16 / _political_a_1
                                :L-INDEX-of (x12 / _and_c
                                        :R-INDEX (x9 / _currency_n_1
                                                :ARG2-of (e10 / compound))))
                        :ARG1-of e10)
                :ARG2 (x26 / _fund_n_1
                        :BV-of (_4 / _the_q))))
```

6. Modality

- Modality also has specific scope in DRS. The modality structure in DRS is:

  B POS B': there is a DRS-condition ◇ B' (it is possible that) in DRS B;
  B NEC B': there is a DRS-condition □ B' (it is necessary that) in DRS B.

6. Modality

A top Hamas leader also suggested his group might agree to future negotiations with Israel through a third party .

DRS(TOPIC(S1 X1) top(S1) hamas(X2) IN(X1 X2) leader(X1) suggest(E1) AGENT(E1 X1) TOPIC(E1 P1) also(E1) P1(DRS(POS(DRS(MALE(X3) OF(X4 X3) group(X4) agree(E2) AGENT(E2 X4) TOPIC(S2 X5) future(S2) negotiation(X5) israel(X6) with(X5 X6) to(E2 X5) TOPIC(S3 X7) third(S3) party(X7) through(E2 X7)))))

B POS B': there is a DRS-condition ◇ B' in DRS B;

```
(E1 / suggest
        :EDGE(E1 / also)
        :AGENT (X1 / leader
                :IN (X2 / hamas)
                :TOPIC-of (S1 / top))
        :TOPIC (E2 / agree
                :arg1-of POS
                :AGENT (X4 / group
                        :OF (X3 / MALE))
                :to (X5 / negotiation
                        :with (X6 / israel)
                        :TOPIC-of (S2 / future))
                :through (X7 / party
                        :TOPIC-of (S3 / third))))
```

Negation and Modality

- However, we have both modality and negation in this sentence.
- *Some hard-liners fear they will not be properly represented in the Fatah list .*

DRS(hard-liner(X1) fear(E1) EXPERIENCER(E1 X1) STIMULUS(E1 P1) P1(DRS(THING(X2) NOT(DRS(NEC(DRS(represent(E2) THEME(E2 X2) fatah(X3) OF(X4 X3) list(X4) in(E2 X4) properly(E2))))))))

B NEC B': there is a DRS-condition □ B' in DRS B.

```
(E1 / fear
      :EXPERIENCER (X1 / hard-liner)
      :STIMULUS (E2 / represent
            :EDGE(E2 / properly)
            :polarity -
            :arg1-of NEC
            :THEME (X2 / THING)
            :in (X4 / list
                  :OF (X3 / fatah))))
```

6. Modality

Some hard-liners fear they will not be properly represented in the Fatah list .

DRS(hard-liner(X1) fear(E1) EXPERIENCER(E1 X1) STIMULUS(E1 P1) P1(DRS(THING(X2) NOT(DRS(NEC(DRS(represent(E2) THEME(E2 X2) fatah(X3) OF(X4 X3) list(X4) in(E2 X4) properly(E2))))))))

(E1 / fear
:EXPERIENCER (X1 / hard-liner)
:STIMULUS (E2 / represent
:EDGE(E2 / properly)
:arg1-of NEC
:arg1-of NEG
:THEME (X2 / THING)
:in (X4 / list
:OF (X3 / fatah))))

7. Quantification

- AMR does not have a deep representation for quantifiers. It only canonicalizes their position:

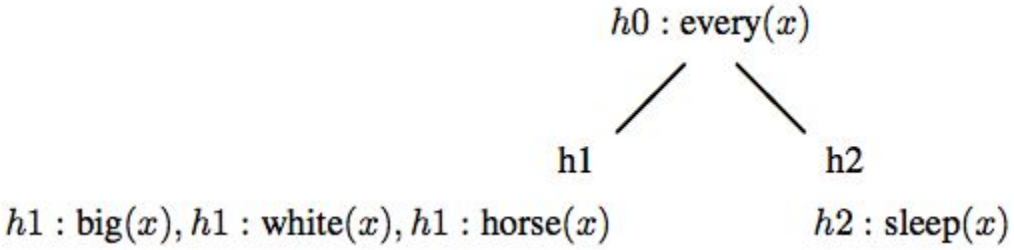
  The boys all left.

  ```
  (l / leave-01
        :ARG0 (b / boy
              :mod (a / all )))
  ```

7. Quantification

- Though in MRS, the lexical types for quantifiers like some and every introduce a quant-relation which is also a subtype of arg0-relation, the AMR-styled MRS, which is derived from EDS, is without the scope.

- *Every big white horse sleeps.*



Every time he sees me, he gets very nervous.

```
(e3 / _get_v_state
      :ARG1 (x24 / pron
            :ARG1-of (e31 / _nervous_a_about
                  :ARG1-of (e30 / _very_x_deg)
                  :ARG2-of e3))
      :ARG1-of (e4 / loc_nonsp
            :ARG2 (x6 / _time_n_of
                  :ARG2-of (e11 / loc_nonsp
                        :ARG1 (e12 / _see_v_1
                              :ARG1 (x14 / pron)
                              :ARG2 (x18 / pron)))
```

7. Quantification

- DRS represents universal quantification as following:

  B IMP B' B'': DRS B contains DRS-condition B' ⇒ B'' (conditional)

U.S. officials have acknowledged that Washington faced problems delivering everything Iraq needed .

DRS(u.s.(X1) IN(X2 X1) official(X2) acknowledge(E1) AGENT(E1 X2) TOPIC(E1 P1) P1(DRS(washington(X3) problem(X4) EQ(X4 X5) face(E2) AGENT(E2 X3) THEME(E2 X4) IMP(DRS(THING(X6)) DRS(iraq(X7) EQ(X6 X8) need(E3) PIVOT(E3 X7) THEME(E3 X8) deliver(E4) AGENT(E4 X5) THEME(E4 X6))))))

```
(E1 / acknowledge
      :AGENT (X2 / official
            :IN (X1 /u.s.)
      :TOPIC (P1 /  face
            :AGENT (X3 / washington)
            :THEME (X4 / problem
                  :AGENT-of (E4 / deliver
                        :THEME-of (X6 / THING
                              :arg0-of IMP
                                    :arg1 E4
                              :THEME (E3 / need
                                    :PIVOT (X7 / iraq))
                              :THEME-of E4)))))
```

B IMP B' B": DRS B contains DRS-condition B' ⇒ B" (conditional)

8. Tense

- AMR 1.2 does not represent event times

The boy goes.
The boy will go.
The boy went.

```
(g / go-02
        :ARG0 (b / boy))
```

8. Tense

- In full MRS, every predicate is annotated with a set of features, encoding information like tense, aspect and number. For example,

- *By 1997, almost all remaining uses of cancer-causing asbestos will be outlawed.*, the root index will be represented as:

  INDEX: e3 [e SF: PROP TENSE: FUT MOOD: INDICATIVE PROG: - PERF: -]

- However, EDS omits this information, and in our AMR-styled MRS, we do not currently model these features.

8. Tense

- DRS uses time referent to represent tense and temporal information.
- T < now means this event happened in the past, there are also T = now and T > now.

Marilyn Monroe died 33 years ago.

```
b1 REF x1                  % Marilyn~Monroe [0...14]
b1 Name x1 "marilyn~monroe"  % Marilyn~Monroe [0...14]
b1 female "n.02" x1         % Marilyn~Monroe [0...14]
b2 REF e1                  % died [15...19]
b2 Patient e1 x1           % died [15...19]
b2 TPR t1 "now"            % died [15...19]
b2 die "v.01" e1           % died [15...19]
b2 REF t1                  % died [15...19] ago [29...32]
b2 Time e1 t1              % died [15...19] ago [29...32]
b2 time "n.08" t1          % died [15...19] ago [29...32]
b2 REF t2                  % 33 [20...22]
b2 Quantity t2 "33"        % 33 [20...22]
b2 Unit t2 "year"          % years [23...28]
b2 measure "n.02" t2       % years [23...28]
b2 TAB t1 t2               % ago [29...32]
b2 TAB t2 "now"            % ago [29...32]
                           % . [32...33]
```

9. Co-reference

- In AMR, If two variables are the same, then they refer to the same entity:

The boy wants to believe himself.

```
(w / want-01
        :ARG0 (b / boy)
        :ARG1 (b2 / believe-01
                : ARG0 b
                :ARG1 b))
```

9. Co-reference

Their voting early surprised me.

```
(s / _surprise_v_1
        :ARG1 (n / nominalization
                :ARG1-of (p / poss
                        :ARG2 (p2 / pron))
                :ARG1 (v / _vote_v_1
                        :ARG1 p2
                        :ARG2 (t / time_n
                                :ARG1-of (e / _early_a_1))))
        :ARG2 (p3 / pron))
```

9. Co-reference

Sylvester Stallone faces stiff fines in Australia , where he is accused of importing a muscle-building hormone .

DRS(sylvester(X1) EQ(X2 X1) stallone(X2) TOPIC(S1 X3) stiff(S1) fine(X3) face(E1) AGENT(E1 X2) THEME(E1 X3) australia(X4) where(X4 P1) in(E1 X4) P1(DRS(MALE(X2) accuse(E2) THEME(E2 X2) TOPIC(S2 X5) muscle-building(S2) hormone(X5) import(E3) AGENT(E3 X6) THEME(E3 X5) of(E2 E3))))

```
(E1 / face
        :AGENT (X2 / stallone
                :EDGE (X2 / MALE)
                :EQ (X1 / sylvester)
                :THEME-of (E2 / accuse
                        :THEME (X2 / MALE)
                        :of (E3 / import
                                :AGENT X6
                                :THEME (X5 / hormone
                                        :TOPIC-of (S2 / muscle-building)))))
        :THEME (X3 / fine
                :TOPIC-of (S1 / stiff))
        :in (X4 / australia
                :where P1))
```

9. Co-reference

Also Wednesday , a former mayor of the Bosnian town of Zvornik turned himself into a war crimes court in Serbia .

DRS(TOPIC(S1 X1) former(S1) mayor(X1) bosnia(X2) of(X3 X2) town(X3) zvornik(X4) of(X3 X4) of(X1 X3) MALE(X5) turn(E1) AGENT(E1 X1) PATIENT(E1 X5) war(X6) of(X7 X6) crime(X7) court(X8) in(X7 X8) to(E1 X7) in(E1) serbia(X9) in(E1 X9) wednesday(X10) in(E1 X10) also(E1))

```
(E1 / turn
        :EDGE(E1 / into)
        :EDGE(E1 / also)
        :AGENT (X1 / mayor
                :of (X3 / town
                        :of (X2 / bosnia)
                        :of (X4 / zvornik))
                :TOPIC-of (S1 / former))
        :PATIENT (X5 / MALE)
        :to (X7 / crime
                :of (X6 / war)
                :in (X8 / court))
        :in (X9 / serbia)
        :in (X10 / wednesday))
```

Questions

1. Do we want to define a lexicon for UMR?
2. Do we want to keep all the name entities in AMR?
3. How to represent relations like *cause*, represent them with *concepts*?
4. *:polarity -* or *NEG*?
5. Still represent modality with concepts?
6. How to introduce quantifier?