From frames to inference:

Event representation in FrameNet and beyond

Part 2: even beyonder!

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[with/for collaborators
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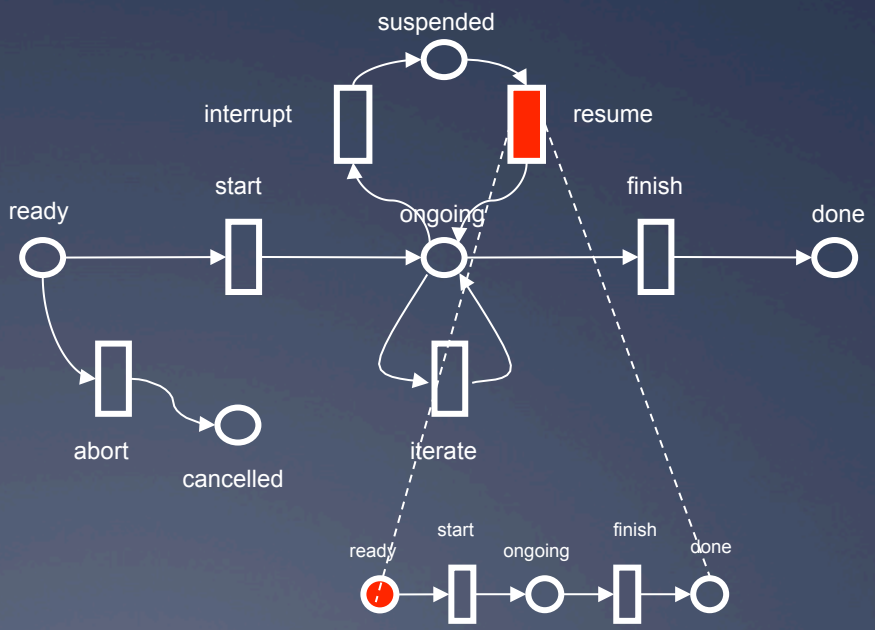
Steve Sinha, …]

FrameNet Workshop
Tuesday, September 10, 2013



Frames linked to
dynamic event representations
can support
rich simulation-based inference.

- Introduction: frames and motor control
- Simulation semantics
- **Inference in action: applications**

Inference in action: applications

- **Aspect** *(Narayanan 1997; Chang, Gildea & Narayanan 1998)*
  - Harry **is walking** to the cafe.
- **Perspective** *(Chang, Narayanan & Petruck 2002)*
  - Chuck **bought** a car from Jerry.
- **Question Answering** *(Sinha 2008)*
  - *Is Syria capable of producing nuclear weapons?*
- **Aspectual composition + Metaphor**
  - *Harry left the store **for an hour**.*

    (Chang, Gildea & Narayanan 1998; Chang 2011)
  - *France **stumbled** into a recession.* *(Narayanan 1997)*

Answering Questions about Complex Events (Sinha 2008)

Analysts are getting deluged by data

Many questions they have to answer with the data are, implicitly or explicitly, about event interactions

Reasoning Goals of Event Model

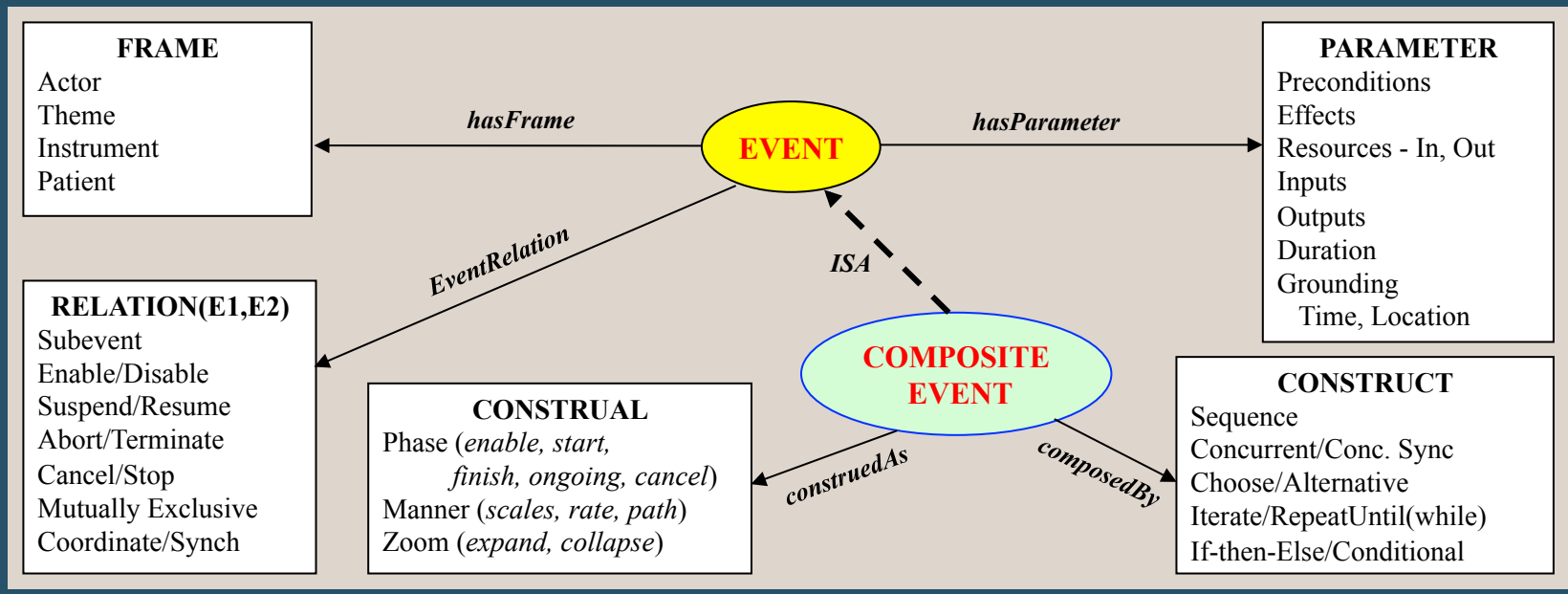
Tackle prominent question types

Justification	*Is Iran a signatory to the Chemical Weapons Convention?*
Temporal Projection/ Prediction	*What were the possible ramifications of India's launch of the Prithvi missile?*
Ability	*Is Syria capable of producing nuclear weapons?*
"What-if" Hypothetical	*If Canada has Highly Enriched Uranium, is it capable of producing nuclear weapons?*
System Identification	*How does a management action reveal the possibility of legal or illegal programs?*
System Control	*What action is necessary to force management to follow a different trajectory?*

Designed event modeling and inference framework to solve event questions

- Captures event interactions
  - Temporal relations between multiple events
- Structures essential contextual info
- Reasons about
  - Dynamics and Uncertainty
  - Sequentiality and concurrency
  - Asynchronous control
- Domain independent
- Can help answer questions about
  - How states evolve over time
  - How states and actions interact

How do we specify an event? Formalized event schema

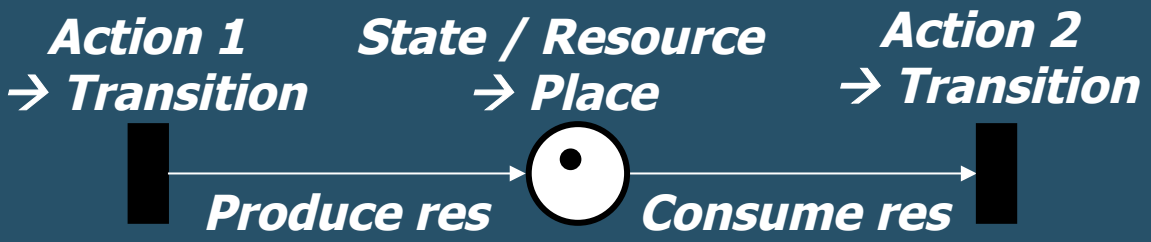


- Key elements
  - preconditions, resources, effects, sub-events
  - evoked by frames (alternatively: predicates, words)
- Contrast with Event Recognition/Extraction, other NLP work
  - [Bethard '07], [Chambers '07]

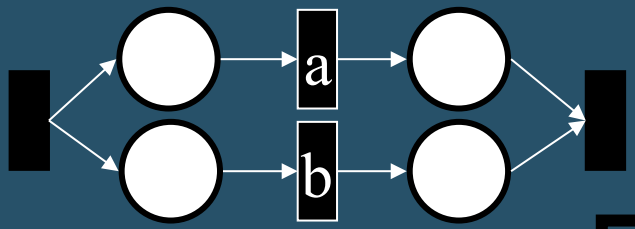
Designed a Dynamic Model of Events

- Representational req's fulfilled by X-net
  - (CPRM: GSPN X-net Event model + belief state)

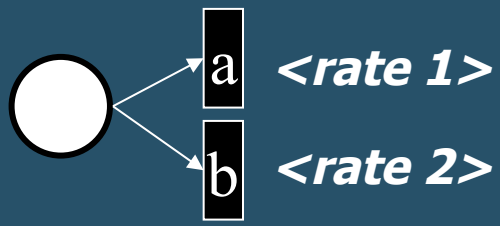
- **Actions & States**
- **Sequentiality**



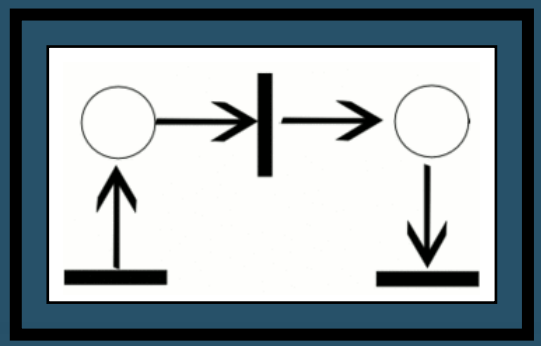
- **Concurrency & Synchronization**



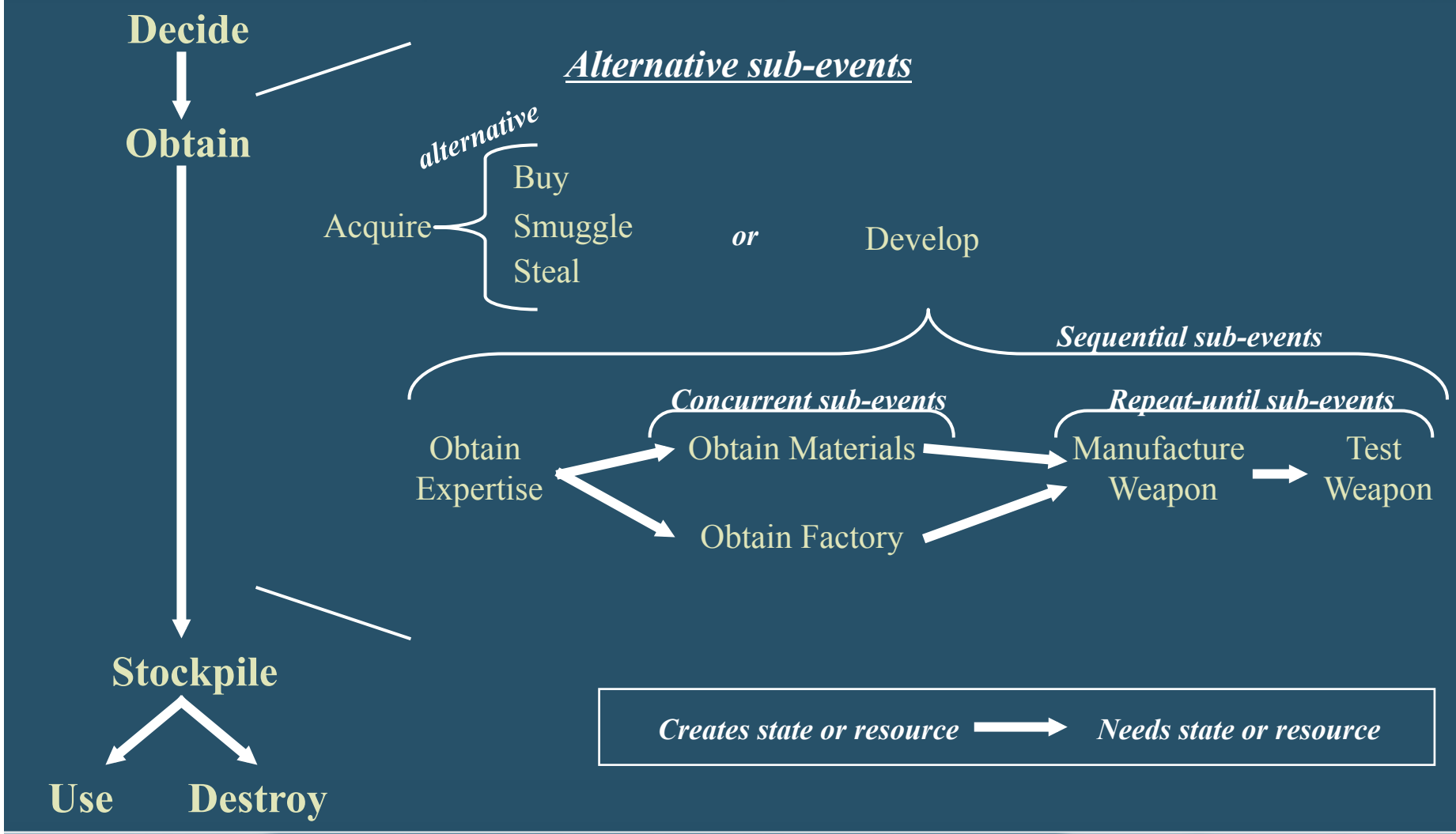
- **Alternative**
- **Stochasticity**



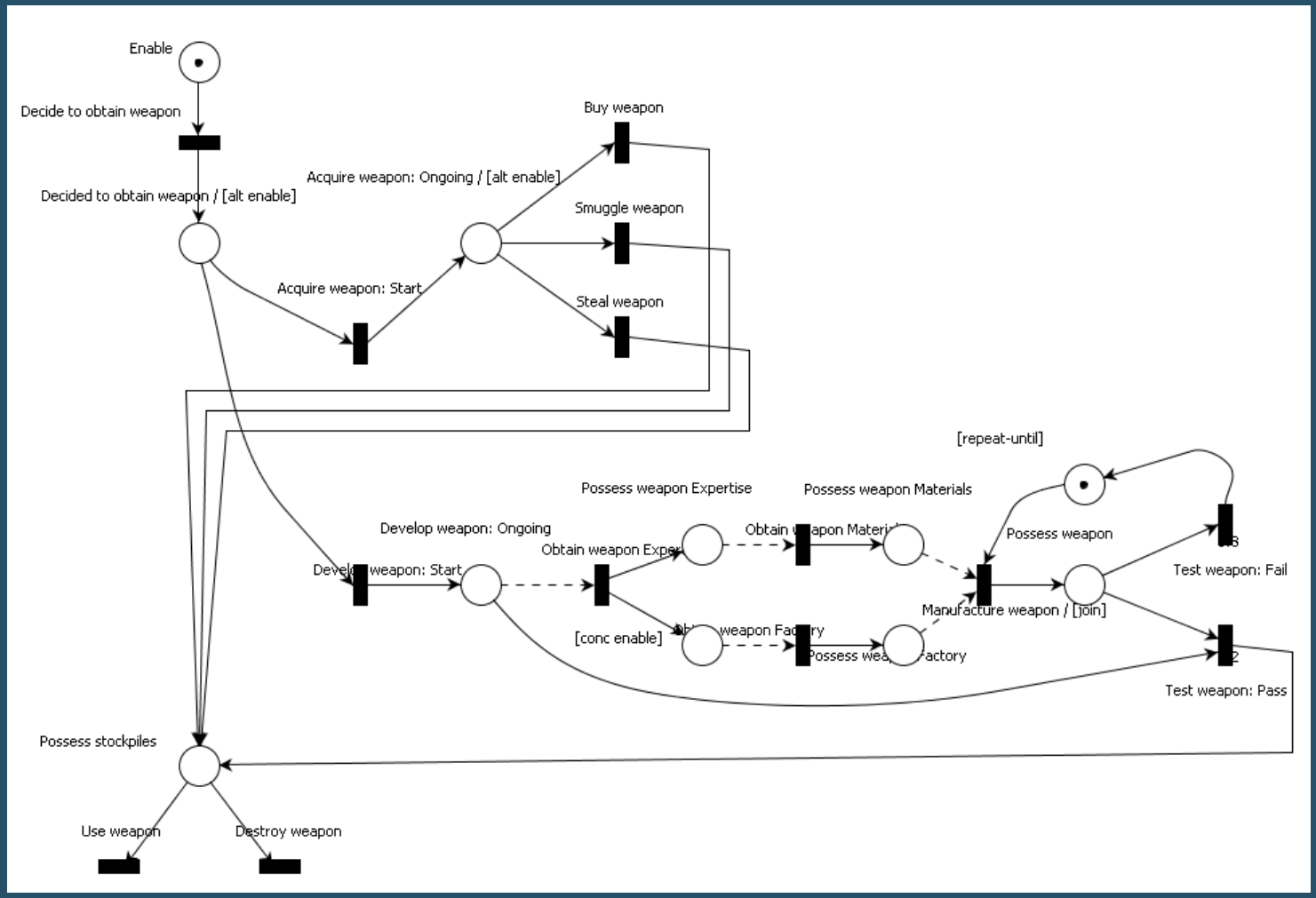
- **Asynchronous Control**



Compose complex scenarios: Obtain WMD model

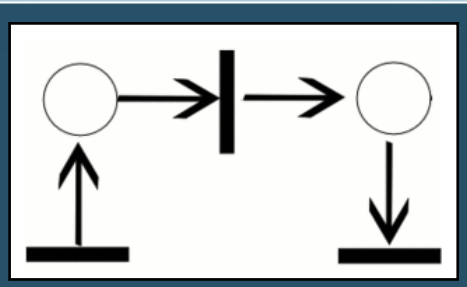


Obtain WMD model can be represented as X-net



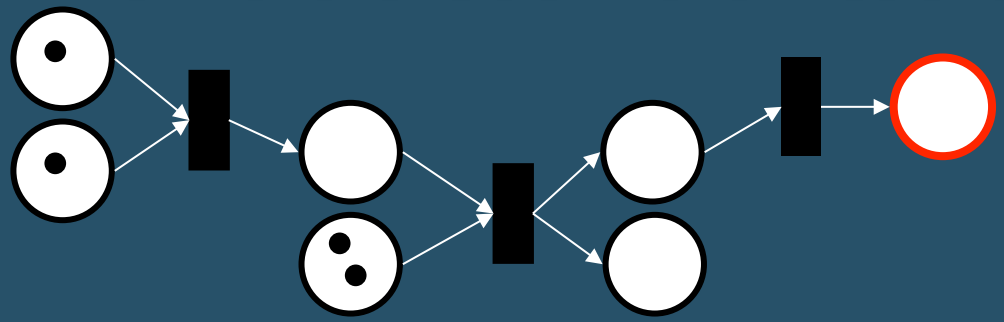
X-Net Analysis Techniques

- Simulation



Transition can fire when: in-tokens > in-arc weight

- Forward & Backward Reachability



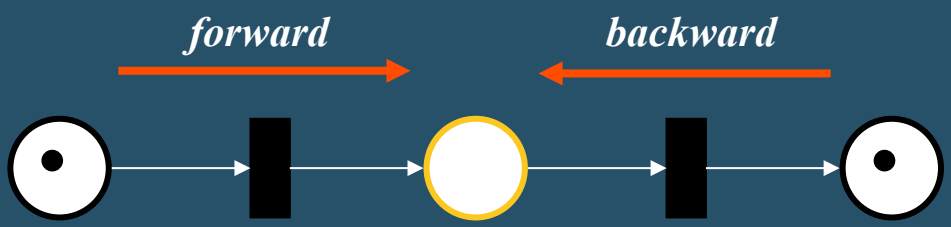
Can Place be reached with initial marking?

[Karp-Miller, '69]

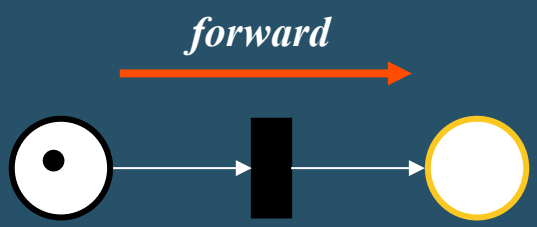
- Steady state probability
- Most likely path (Viterbi)
- w/BN: Prediction/Smoothing/Filtering/MAP

Reachability analysis by Question Type

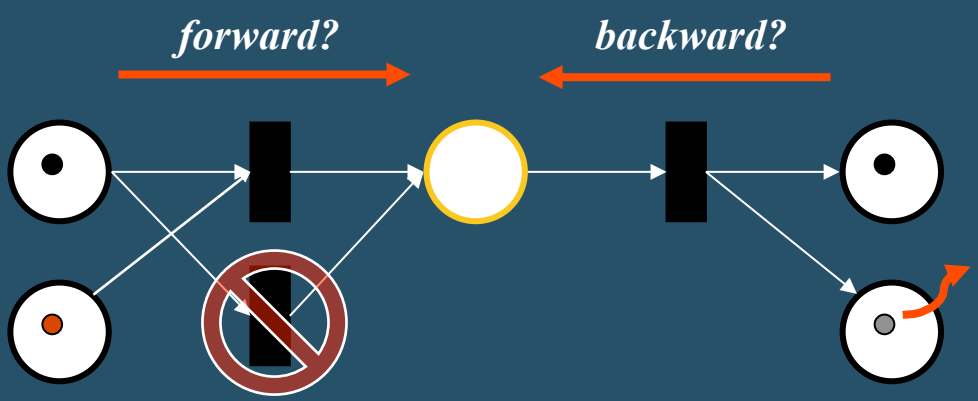
Justification



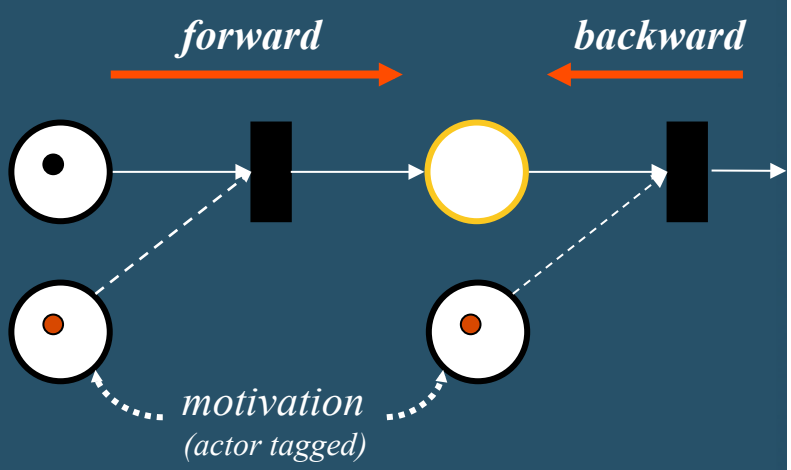
Temporal Projection



"What if" Hypothetical



Ability



- With stochastic transitions, can calculate likelihood of reachable state

Application: Semantic-based Event QA

Research perspective

- Test if Event framework improves QA

Task perspective

- Have means of inferring answer
  - Justification, Projection, What-if Hypothetical, Ability
- How to get evidence?
  - Link question to model through language using frames
  - Infer with Simulation

Basic System: find the exact same frame

Passage: The continued willingness of the Democratic People's Republic of Korea (DPRK), the People's Republic of China (PRC), and Russia to *provide* Iran with both missiles and missile-related technology that at the very least exceed the intentions of the Missile Technology Control Regime (MTCR). This has been complemented, to a lesser extent, by the willingness of other nations (e.g., Libya and Syria) to cooperate within the realm of ballistic missile development.

Question: What countries have *provided* Iran with ballistic missiles and missile-related technology? (lcch 9)

Q Frame: Supply

Supplier: <Country> What countries

Recipient: <Iran> Iran

Theme: <Ballistic_missile> with ballistic missiles and missile-related technology

P Frame: Supply

Supplier: <North_Korea, China, Russia> the Democratic People's Republic of Korea (DPRK), the People's Republic of China (PRC), and Russia

Recipient: <Iran> Iran

Theme: <Missile> with both missiles and missile-related technology ...

The question drives the match

see also [Fliedner, 2004]

Early Test: Event models improve Answer Selection

- Perfect frame matches, you're lucky
- Event Schema
  - Use context to improve keyword search performance
- Answer Selection
  - For question, IR system returns 100 answers
  - Rank order relevant answers

Expand and focus "relevance": Use Event-Language hook

Event: Acquire weapon

- Precondition: Possess will to obtain weapon
- Effect: Possess weapon
- Resource:
- Frame: Getting, Transfer, Sending, Import_export...
- Words: acquire, gain, get, procure, secure, transfer...

Frame: Getting

- FE: Recipient → <country>
- FE: Theme → <weapon>

type constraints

from Obtain WMD model

- Connection between Model and Language
  - Language → Model : question hook to select model
  - Model → Language : model hook to select evidence

Event model extends matching capability

Question

Does Egypt possess BW stockpiles?

Possession [Own:Egypt, Pos:BW]

Index into event models

Getting [Rec:Egypt, Thm:BW]
Theft [Perp:Egypt, Gds:BW]
Commerce_buy [Byr:Egypt, Gds:BW]
Manufacturing [Man:Egypt, Pro:BW]
Storing [Agt:Egypt, Thm:BW]
...

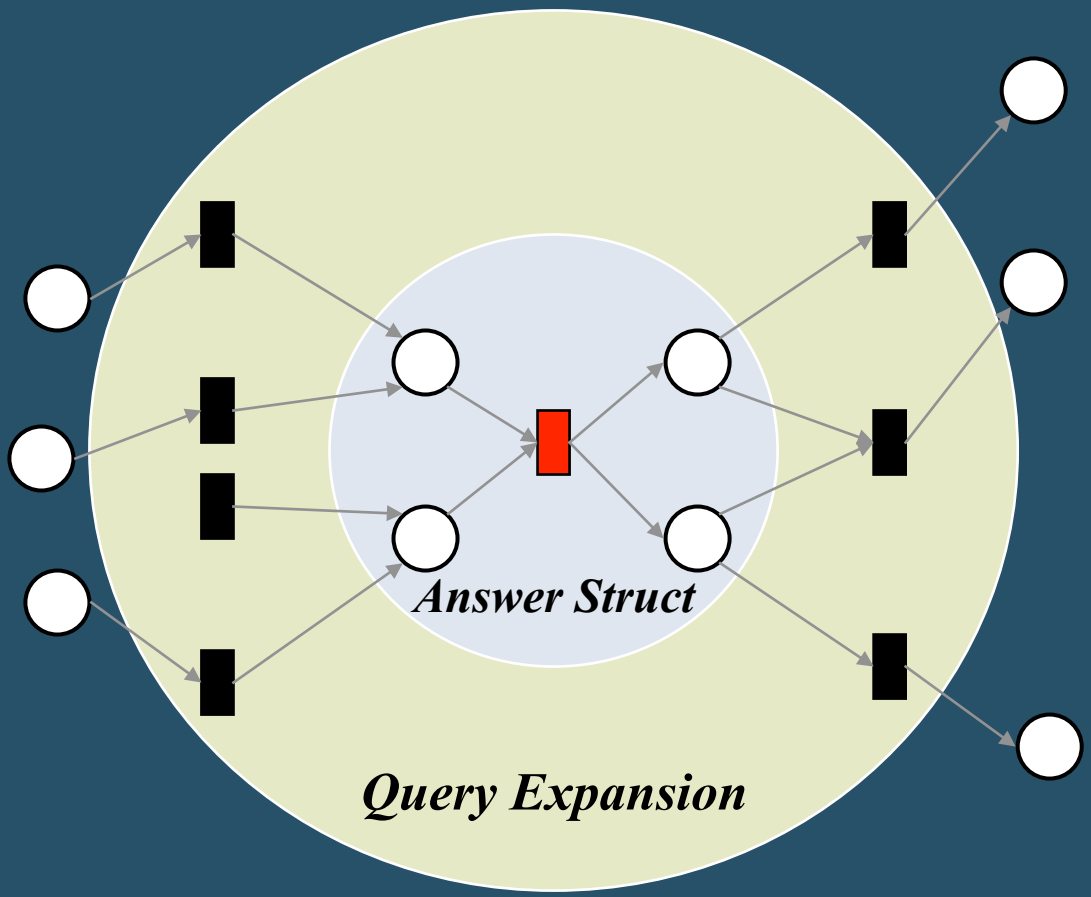
Answer Candidate #4

"... Egypt bought BW."

Commerce_buy [Byr:Egypt, Gds:BW]

MATCH!

Query Expansion and Answer Structure



Guided feedback to front-end

- Causally related Answer Structure
  - Double down on missing info
- Relevant Query Expansion
  - Can be end in and of itself

Does Joe drive a Ferrari?

Stage 1

Question Analysis

Frames

Operate_vehicle
Driver: *Joe*
Vehicle: *Ferrari*

Question Type

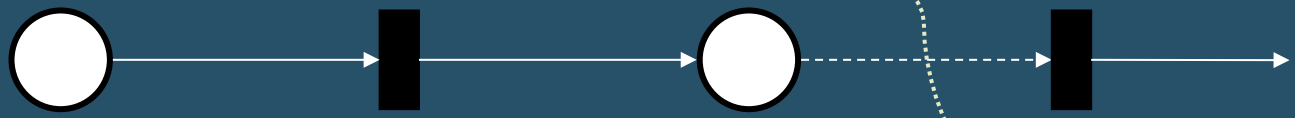
Justification

Test/Relation

Reachable

Model Match

Car ownership scenario



Variable	Binding
v_buyer	*Person*
v_car	*Car*

Possession
Owner: *v_buyer*
Possession: *money*

Commerce_buy
Buyer: *v_buyer*
Goods: *v_car*

Possession
Owner: *v_buyer*
Possession: *v_car*

Operate_vehicle
Driver: *v_buyer*
Vehicle: *v_car*

v_buyer = Person > Joe; v_car = Car > Ferrari

Model Instantiation

Model Frame

Operate_vehicle
Driver: *v_buyer*
Vehicle: *v_car*

Question Frame

Operate_vehicle
Driver: *Joe*
Vehicle: *Ferrari*

Variable	Binding
v_buyer	*Joe*
v_car	*Ferrari*

Query Expansion Setup

- Copy and gather frames of Drive's neighboring actions & states.
- Transfer variable bindings.
- Submit to IR system.

Does Joe drive a Ferrari?

Stage 2

Passage Search

Matching Passages

(one match)
Joe bought a Ferrari

Frames

Commerce_buy
Buyer: *Joe*
Goods: *Ferrari*

Add Evidence Tokens

(for evidence matching actions, tokens added through outgoing arcs)

Car ownership scenario

$$$ — Buy — Own — Drive

Variable	Binding
v_buyer	*Joe*
v_car	*Ferrari*

Possession
Owner: *v_buyer*
Possession: *money*

Commerce_buy
Buyer: *v_buyer*
Goods: *v_car*

Possession
Owner: *v_buyer*
Possession: *v_car*

Operate_vehicle
Driver: *v_buyer*
Vehicle: *v_car*

Model Analysis

Question Type
Justification

Complete reachability analysis and test

Results: Drive is reachable from Own

Compile Answer

Return "Yes/Possible" along with evidence: "*Joe bought a Ferrari*"

Evaluated on Complex Event Models

- More than a dozen complex models
  - Treaty Process
  - Obtaining WMDs (general)
  - Biological WMD Production
  - Israel-Lebanon Conflict
  - Criminal Process
  - Employment
  - Commercial Transaction
  - …

Inference in action: applications

- **Aspect** *(Narayanan 1997; Chang, Gildea & Narayanan 1998)*
  - Harry **is walking** to the cafe.
- **Perspective** *(Chang, Narayanan & Petruck 2002)*
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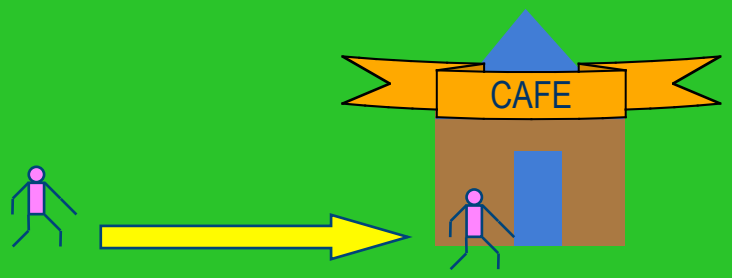
    (Chang, Gildea & Narayanan 1998; Chang 2011)
  - *France **stumbled** into a recession.* *(Narayanan 1997)*

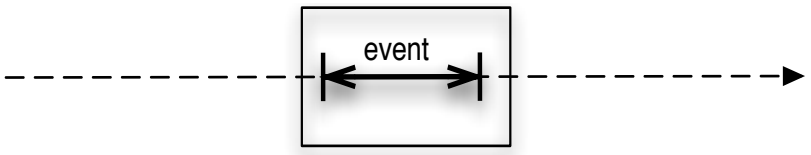
Temporal and event structure

Different tense and aspect markings yield different scenes and inferences:

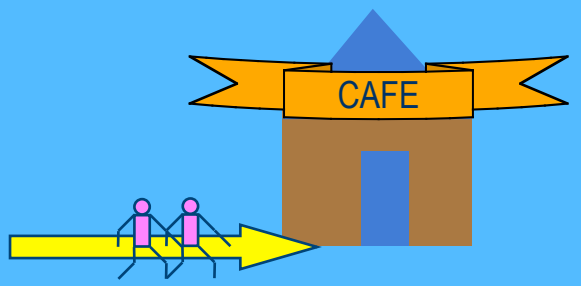
"Harry walked to the cafe."



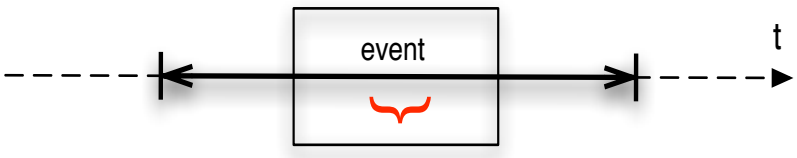
- action = **before** speech time
- goal **reached**
- profile = **entire event**



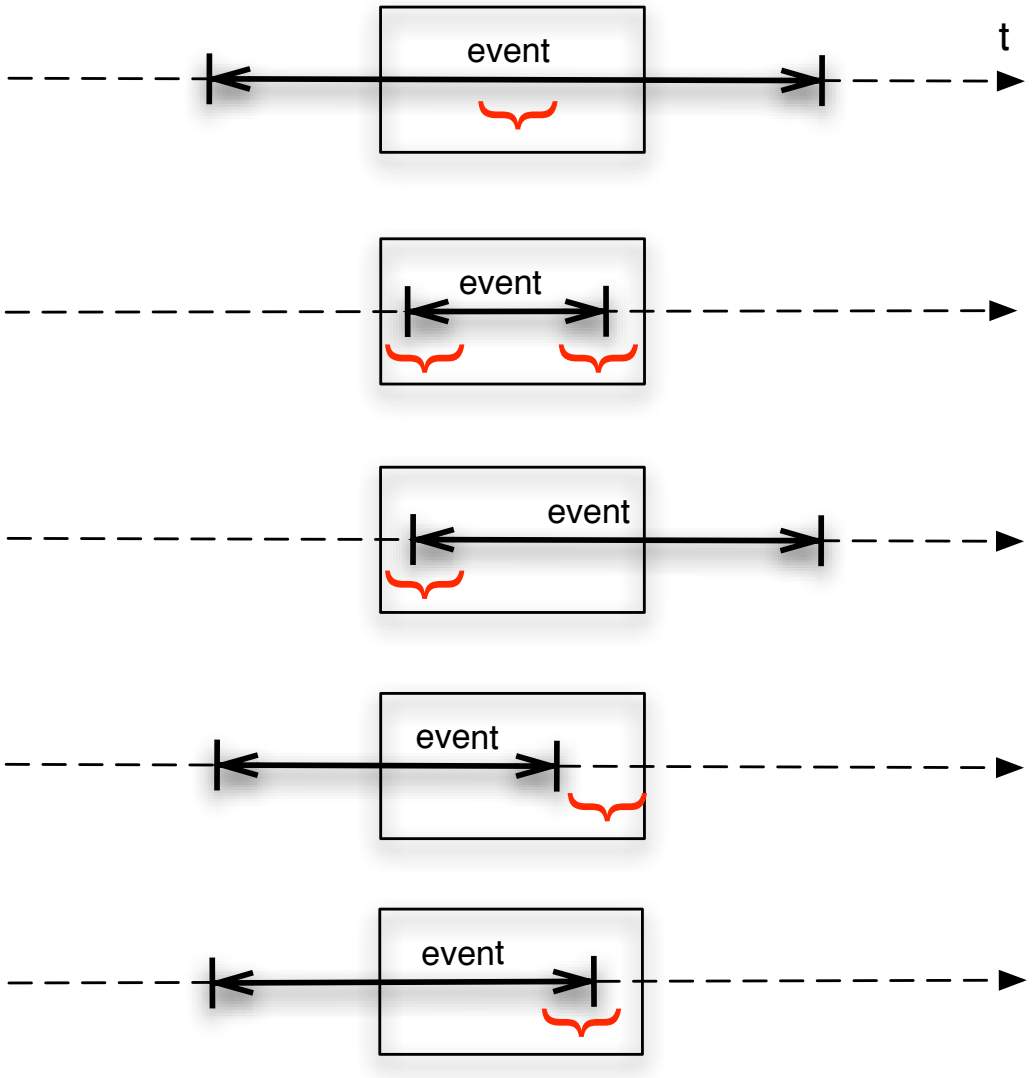
"Harry is walking to the cafe."



- action = **at** speech time
- goal **unreached**
- profile = **ongoing / in progress stage**



English phasal aspect



progressive **be** V-**ing**
is *walk**ing***

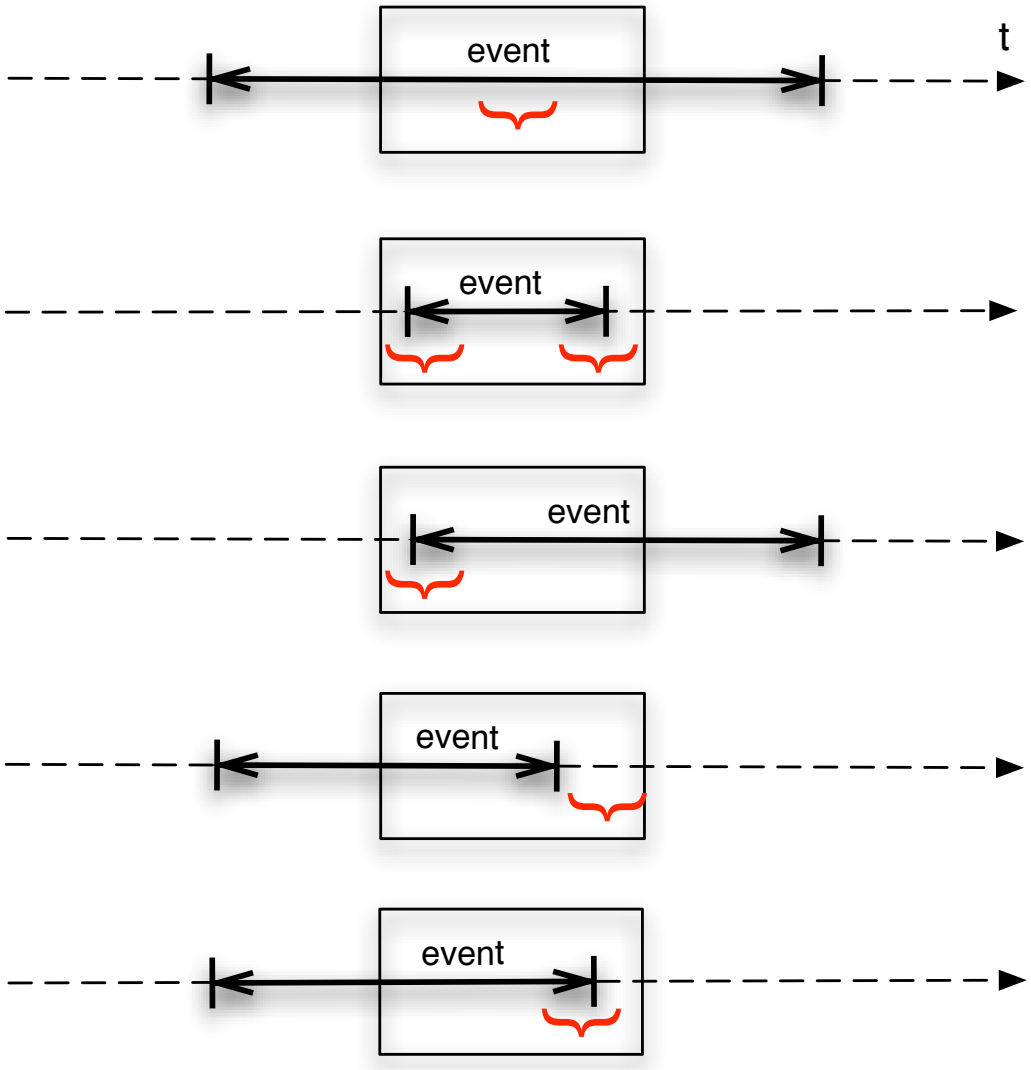
durative V (**for a minute**)
*walk (**for a minute**)*

inceptive **start** V-**ing**
start *walk**ing***

perfect **have** V-**ed**
have *walk**ed***

terminative **finish** V-ing
finish *walking*

Mandarin aspectual markers



progressive **zhèngzài** V
zhèngzài zǒu

durative V **yīhuír**
*zǒu **yīhuír***

inceptive **kāishǐ** V
kāishǐ zǒu

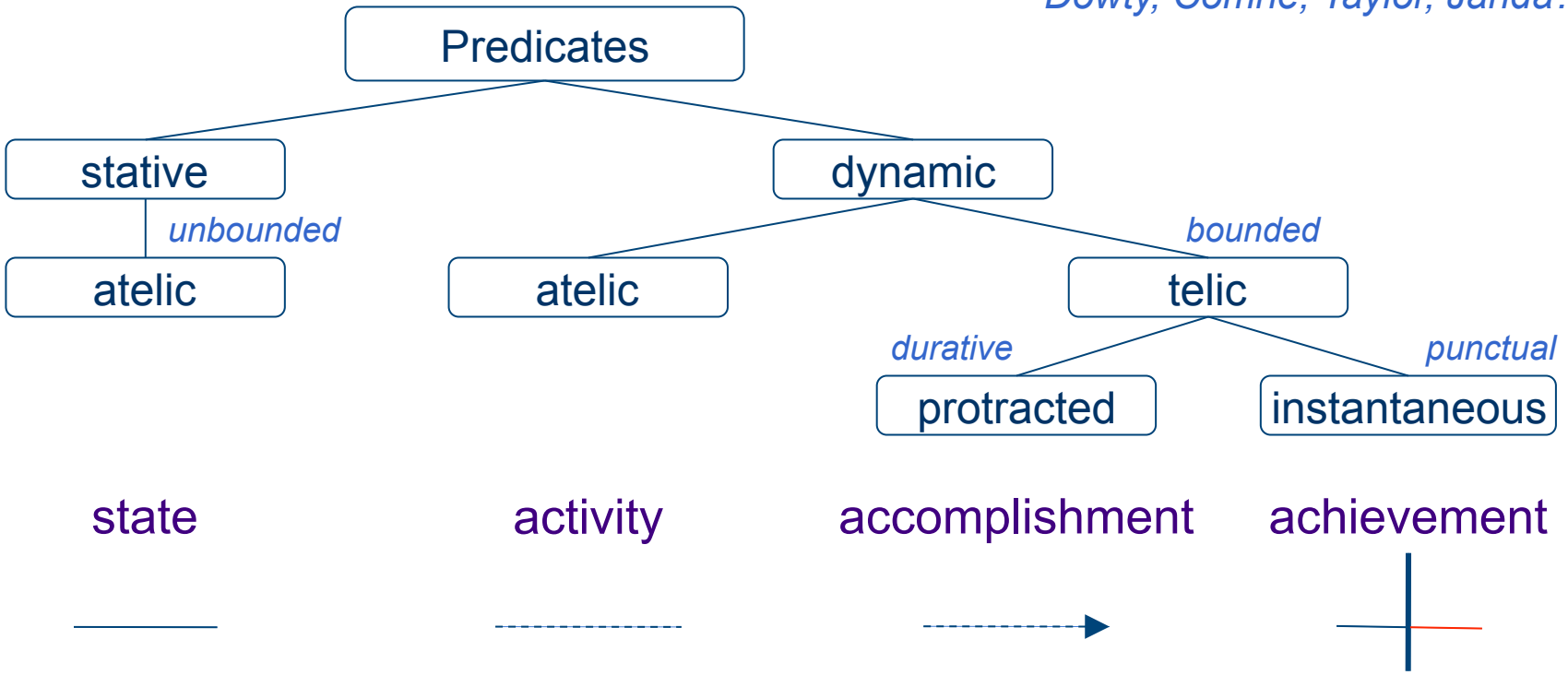
realized V **le**
*zǒu **le***

terminative V **wán (?)**
*zǒu **wán***

Aspectual classes: Vendler

- Zeno Vendler (1967) distinguished 4 aspectual classes

…and many more from others!
Dowty, Comrie, Taylor, Janda…



Possible generalizations

- **Stative** predicates do not appear in
  - progressive form
    - *I am knowing the answer.
    - *She is liking him.
  - agentive/voluntary control constructions
    - *Stop knowing the answer.
    - *Stop being eight feet long.
- But:

  I am liking this town more and more. *(process)*

  Stop being such a crybaby. *(intention)*

More challenges

- Temporal modifiers have different effects
  - Mary read the book [**for 5 hours / in 5 hours**]. *(book finished?)*
  - Barry [**stood / swam / sneezed**] for 5 minutes. *(iterated?)*
  - Gary [**swam / left**] for 5 minutes. *(bounded? reversible?)*
  - Terry left [**in / for**] 5 minutes. *(modified period? reversible?)*

- Subtle interactions among verb, argument structure, nominals, temporal modifiers, etc.
  - Sherry went to the mall [**for 5 hours / ?in 5 hours**]. *(inceptive?)*
  - Larry ate [**sandwiches / ?a sandwich**] for 5 minutes. *(bounded?)*
  - Carrie [**washed / ?pushed**] **the cart** in 5 minutes. *(telic?)*
  - Perry [**is / is being**] totally ridiculous. *(transient?)*

Interaction with event type

Mary lived in Paris

...?in a year.

…for a year.

Mary swam

...?in an hour

…for an hour

Mary sneezed

...?in an hour

…for an hour (iterative)

Mary left

… ?in an hour

…for an hour (and then came back).

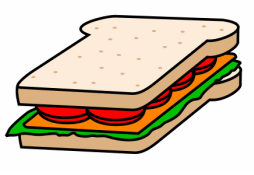
- Lexical aspect matters.

Interaction with object properties

John ate **a sandwich**.

...in an hour

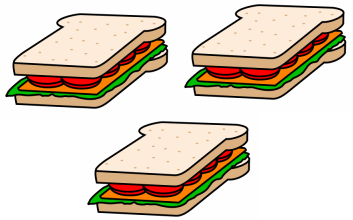
…?for an hour



John ate **sandwiches**.

...?in an hour

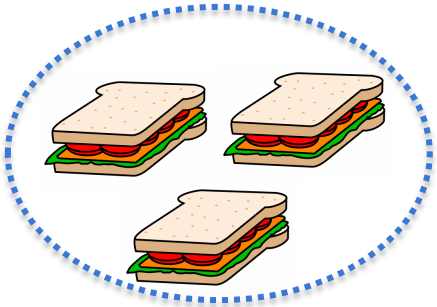
…for an hour



John ate **the sandwiches**.

...in an hour

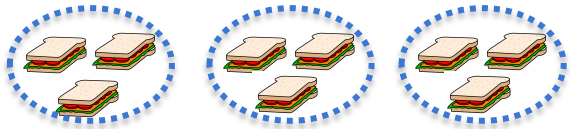
…?for an hour



John ate **the sandwiches every day**.

… in an hour

…?for an hour



- Boundedness & distribution matter!

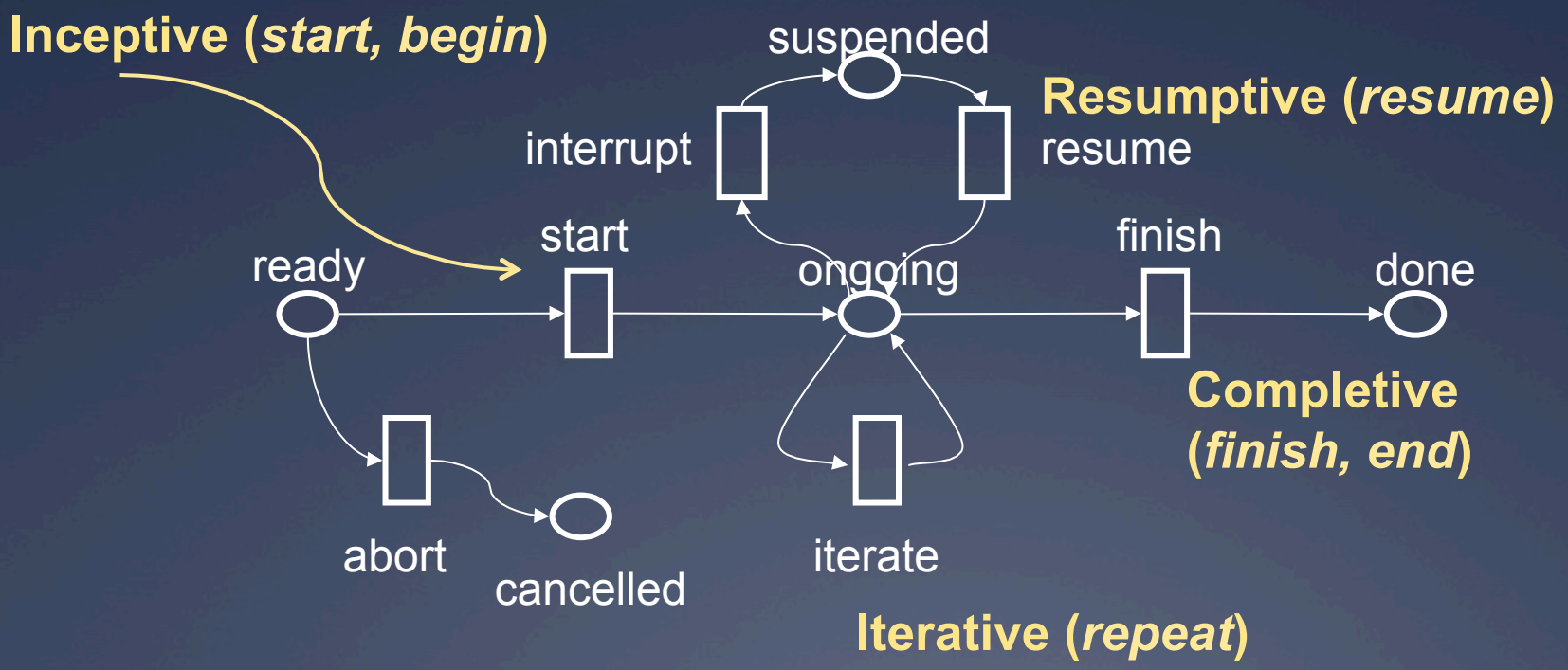
Event-based distinctions

- Action patterns
  - One-shot, repeated, periodic, punctual
  - Decomposition: sequential, concurrent, alternatives
- Goal-based schema enabling/disabling
  - Telicity, change of state
- Generic control features
  - Interruption, suspension, resumption
- Resource usage
  - Production/consumption of time, energy, objects

Richer than traditional classes!

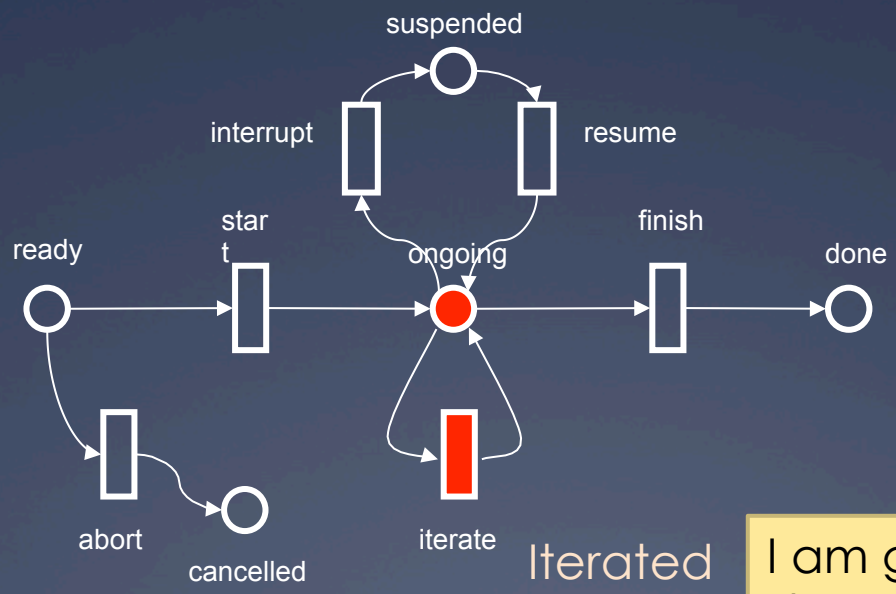
Basic process controller

* A general **controller x-schema** captures the generic event structure associated with a **process**.
* Linguistic constructions can mark (or profile) specific states or transitions in the **controller schema**.



Motivated polysemy

* **Variants of progressive marking may correspond to different simulation parameters.**



Iterated

I am going to the store (every night).

X-schema: Petri net extensions

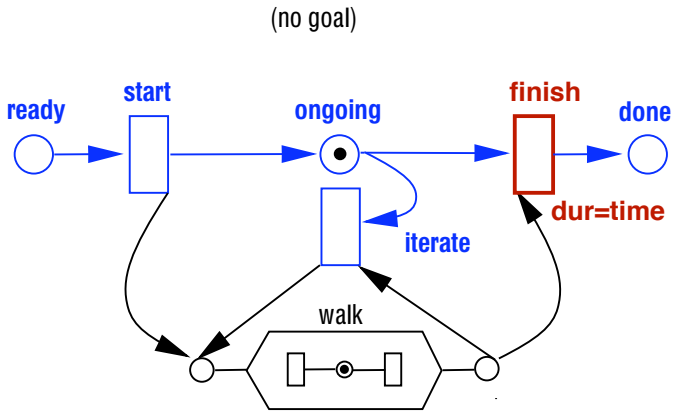
- Parameterization and dynamic binding
  - Variable parameters
    - walk(speed=slow, destination=store1)
  - Variable objects and entities
    - grasp(cup1), push(cart)
- Hierarchical control, durative transitions
  - Subevents
    - walk --> step --> stance, swing phases
  - Time delay for transition firing
    - **walk (duration=5 minutes)**
- Stochastic transitions, inhibition
  - Uncertainty in world evolution and action selection

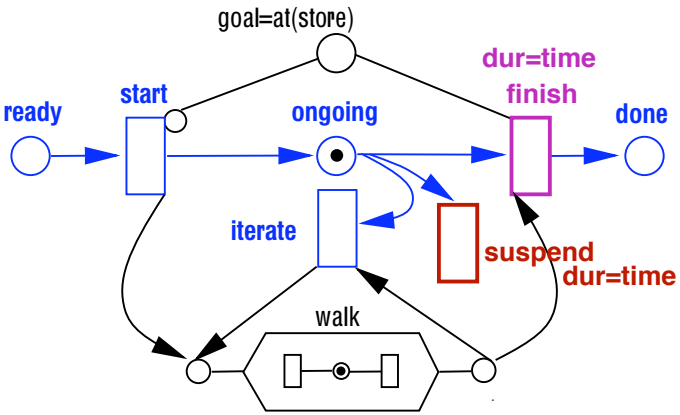
DURATION: TEMPORAL MODIFIERS

- Both *for* and *in* specify durations, but:

  ***for* implies no goal or goal unachieved; *in* implies goal (achieved)**

Processes:





She read for an hour.
*She read in an hour.

She walked for an hour.
*She walked in an hour.

She read the book for an hour.
She read the book in an hour.

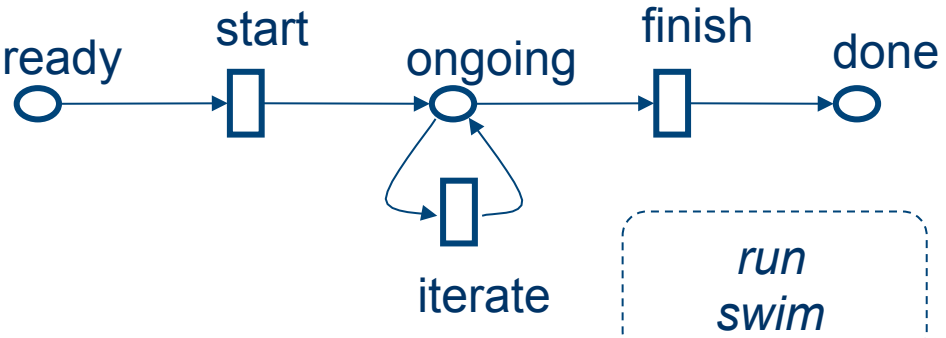
She walked to the store for an hour.
She walked to the store in an hour.

Basic event types

- **States**

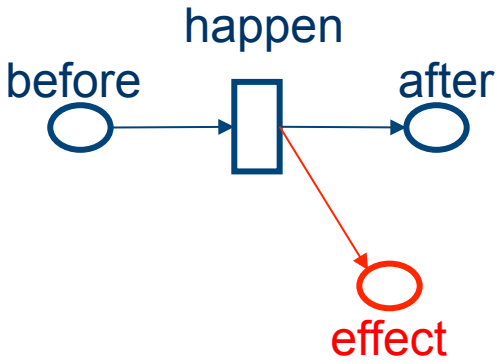
live
have

- **Processes** (continuous)



run
swim

- **Transitions** (discrete)



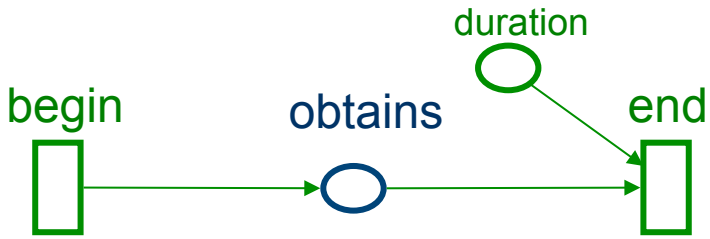
sneeze
leave
win

Aspectual constraints

- Durative modifiers require an interval
  - ***for TIME***: no specific goal achieved (atelic)
  - ***in TIME***: specific goal present/achieved (telic)
  - Interval may be coerced / created
- Interaction between goal and conditions
  - Boundedness of resource linked to specific goal
    - She ate [sandwiches | two sandwiches].
- Ongoing requires a bounded interval
  - May cause inference of iteration, temporariness/ reversability, habitual

Temporal composition: for <TIME>

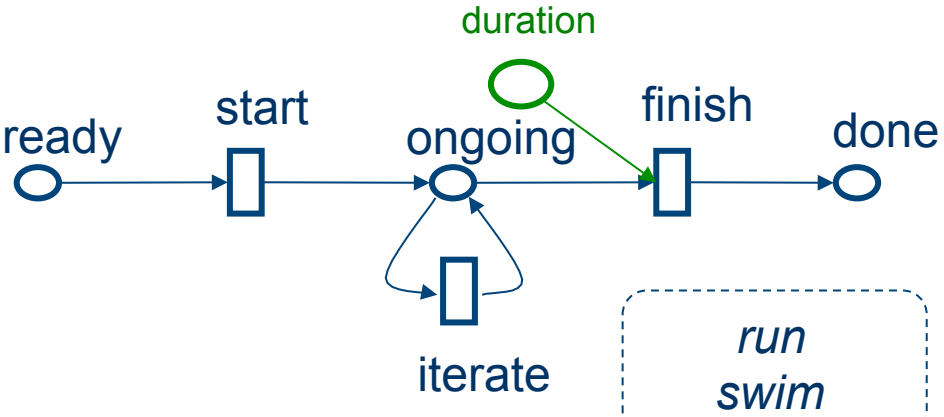
- **States**



live
have

(for now)

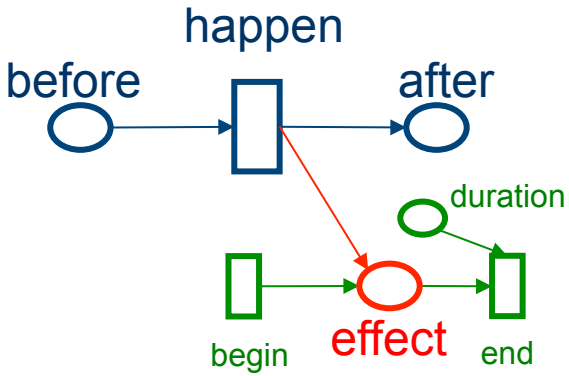
- **Processes** (continuous)



run
swim

(for an hour)

- **Transitions** (discrete)

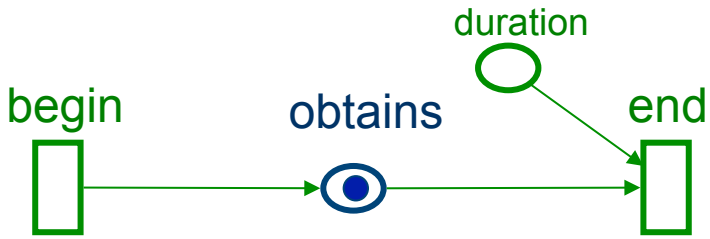


sneeze
leave
win

(for an hour)

V-ing for <Time>

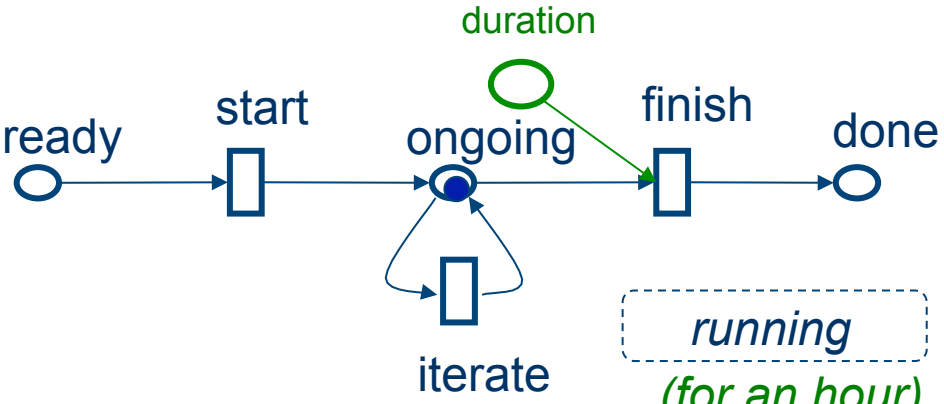
- **States**



living here

(for now)

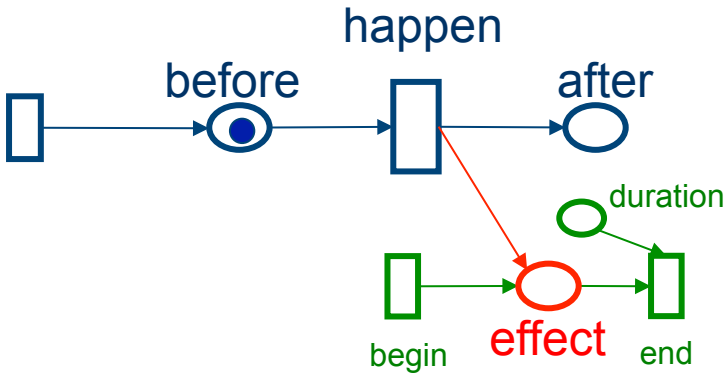
- **Processes** (continuous)



running

(for an hour)

- **Transitions** (discrete)



leaving

(for an hour)

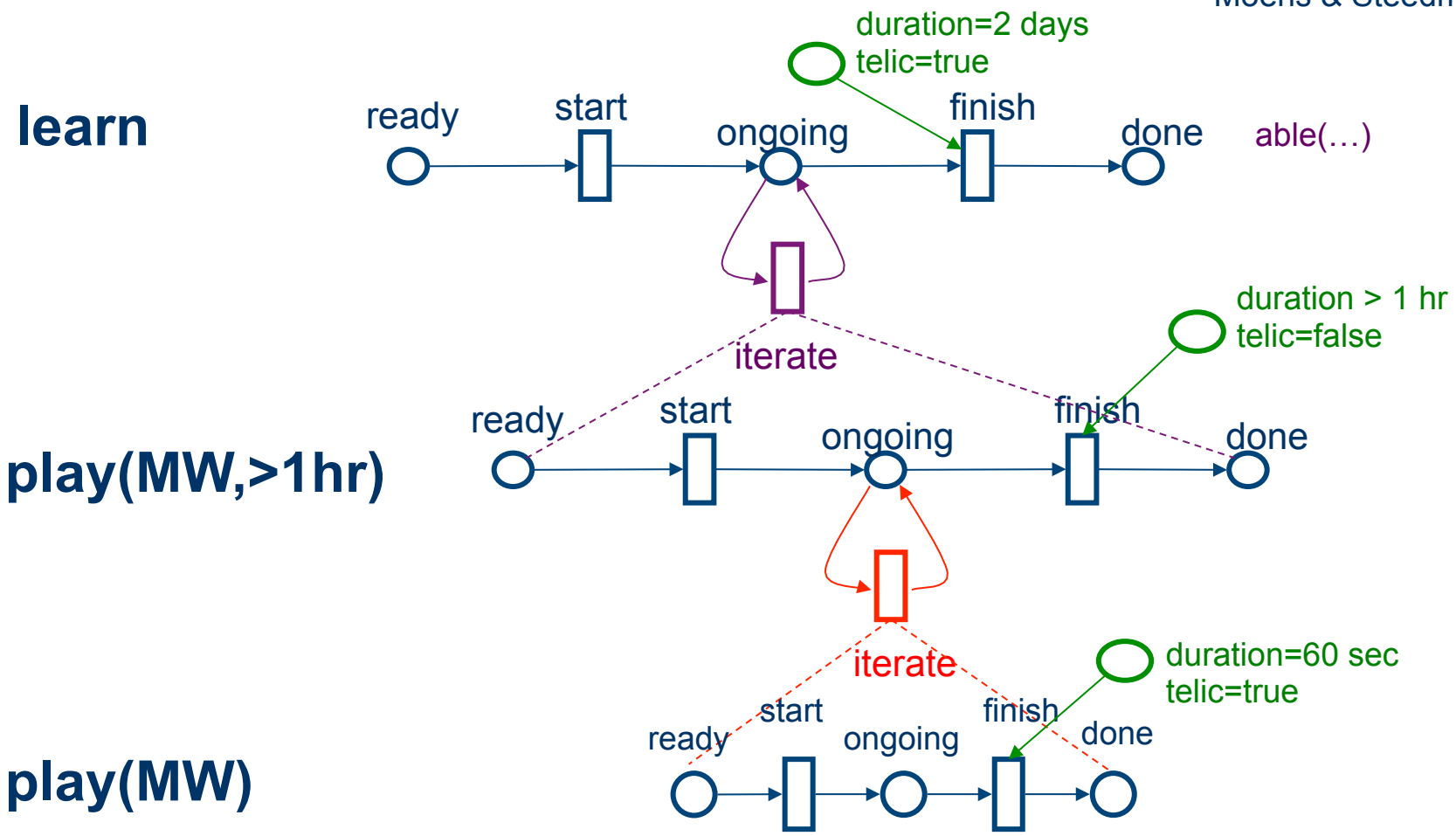
Cognitive operations

- Embodied simulation semantics provides motivated basis for aspectual distinctions as well as possible operations to recover from unexpected combinations.

- Aspectual/event operations
  - **Profile**: She has arrived. / She is swimming.
  - **Zoom in**: She is in the process of leaving.
  - **Iterate**: She sneezed for an hour.
  - **Make habitual**: She sneezes all the time.
  - **Make temporary (infer bound)**: She is living in Paris.
  - **Reverse/undo (infer bound)**: She left for an hour.
  - **Infer inceptive period**: She walked in a month.
  - **Add resource bound**: She was eating three sandwiches.

It took me two days to learn to play the Minute Waltz in 60 seconds for more than an hour.

Moens & Steedman 1988



Constructional interactions

Motivated basis for explaining/predicting dispreferred interactions.

- Ditransitive: cause to receive
  - Harry baked her a cake.
  - *Harry baked her a cake for an hour.
- Irreversible predicates
  - Harry died.
  - ? Harry died for a minute.

…or unexpectedly allowed interactions!

15 October 2003 17:17

Roy Horn - Mauled Roy Died For A Minute, Skull Fragment Kept In Stomach

Caption: Roy Horn (Picture) on hand to tap a keg for Oktoberfest at the restaurant Hofbrauhaus Las Vegas, NV ....

Mauled Roy Died For A Minute, Skull Fragment Kept In Stomach

LATEST: Part of mauled magician ROY HORN's skull was removed and stored in his stomach during a radical operation where the illusionist officially died for almost a minute.

According to American tabloid STAR, the 59-

Roy Horn Photos

Roy Horn Gallery

Top Headlines

- ROBERT PLANT PLAYS LED ZEPPELIN HITS AT SECRET GIG
- KAITLIN OLSON HAD TO SEE HOME RUN BEFORE GIVING BIRTH
- TRANSFORMERS 3 EXTRA UNDERGOES BRAIN SURGERY
- JENNIFER LOPEZ TO BECOME AMERICAN IDOL JUDGE

“died for a minute” ?

- Near- (or past-?)death experiences
  - …a radical operation where the illusionist officially **died for almost a minute**.
  - I've had a cousin who got backed up by a jeepney in the parking lot of Don Bosco Makati in the 1970s, **died for a minute but came back.**
- Bending the rules: vampires & friends
  - Buffy faced The Master and **died. For a minute or two** (Hey! It’s TV!).
  - Long Lost Bro stood by in a previous episode when Melinda **died for a minute**
- Hyperbolic adulators
  - omg i think i just **died for a minute** looking at richie!! one word comes to mind when looking at him...WOWZAAAAAAAAA!
  - omg my heart like **died for a minute...** i thought that she got shot or something
- “Non-functioning” sense (mechanical; **metaphor!**)
  - My internet **died for a minute**

Metaphorical inference

* Economic metaphors
  - France **fell** into recession. Germany **pulled** it **out**.
  - The economy is **moving** at the **pace of a Clinton jog**.
  - The Indian Government is **stumbling** in implementing its liberalization plan.

The Embodiment Hypothesis

* Basic concepts and words derive their meaning from **embodied experience.**

* Abstract and theoretical concepts derive their meaning from **metaphorical maps** to more basic embodied concepts.

“Grasp the idea”

- Understanding is holding / grasping
  - Ideas are objects
- Understanding is seeing
  - Ideas are lightbulbs
  - Getting idea = turning on light

Metaphor understanding system

Indian Government stumbling in implementing liberalization plan

Input

Event	Domain	Actor	Aspect
stumble(IG)	Liberalization Plan	Indian Gov. (IG)	present-progressive

Output

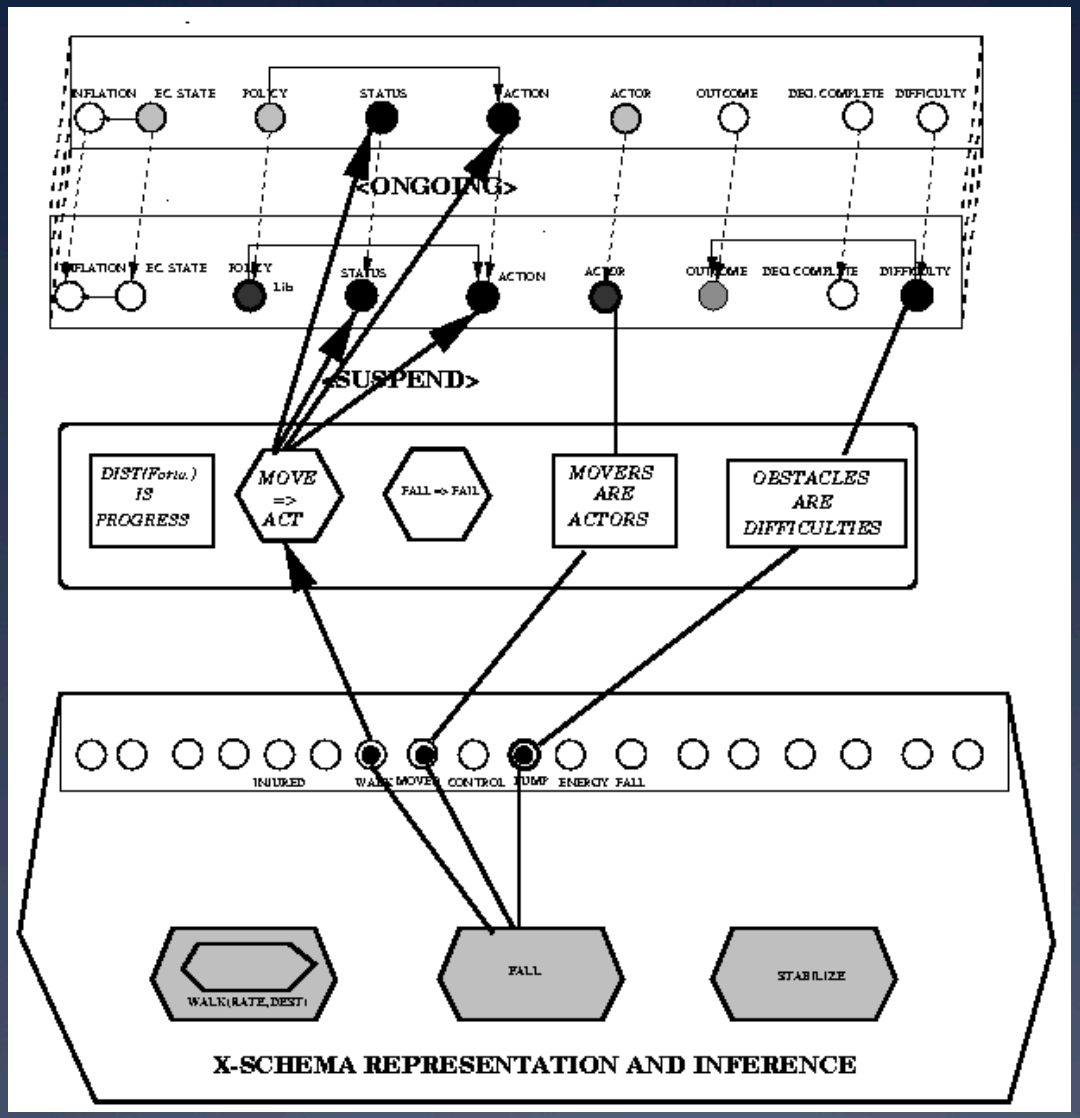
Event	Domain	*Context*	*Status*	*Outcome*	*Goal*
stumble (IG)	Liberaliza-tion Plan	Ongoing plan, **difficulty**	**inter-rupted(.8)**	**failure (.7)**	*free-trade, deregula-tion*

Metaphor system architecture

Target domain

Metaphor maps

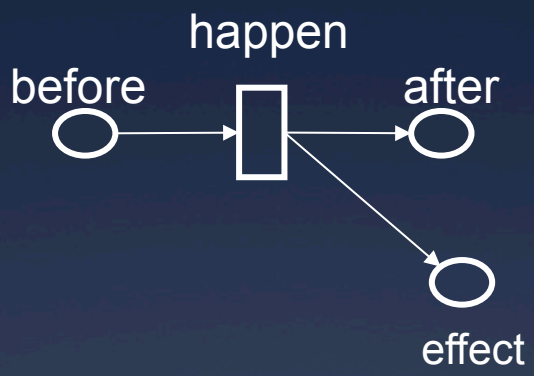
Source domain



(Narayanan 1997)

My internet died for a minute

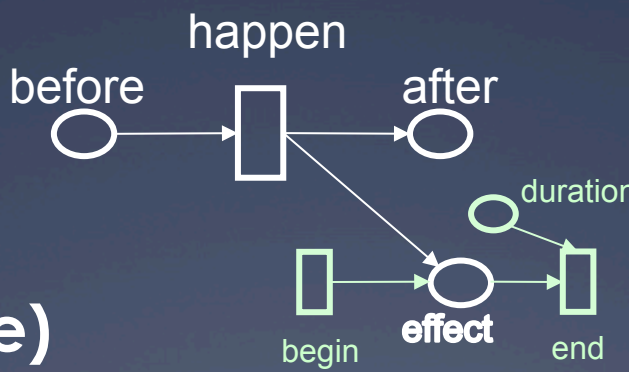
die(Human)



dead(Human)

ALIVE IS FUNCTIONAL

die(internet)



die(internet, a minute)

non-functional(internet)

Frames + simulation = inference

- Simulation semantics framework
  - Dynamic computational model of event structure
- Demonstrated reasoning power of event framework
  - Linguistic issues: aspect, perspective, metaphor
  - Practical applications: question answering

I *am* thank*ing* the lovely audience.