Instrumented Environments

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Mon, 10-12 Uhr, Theresienstr. 39, Room E 46

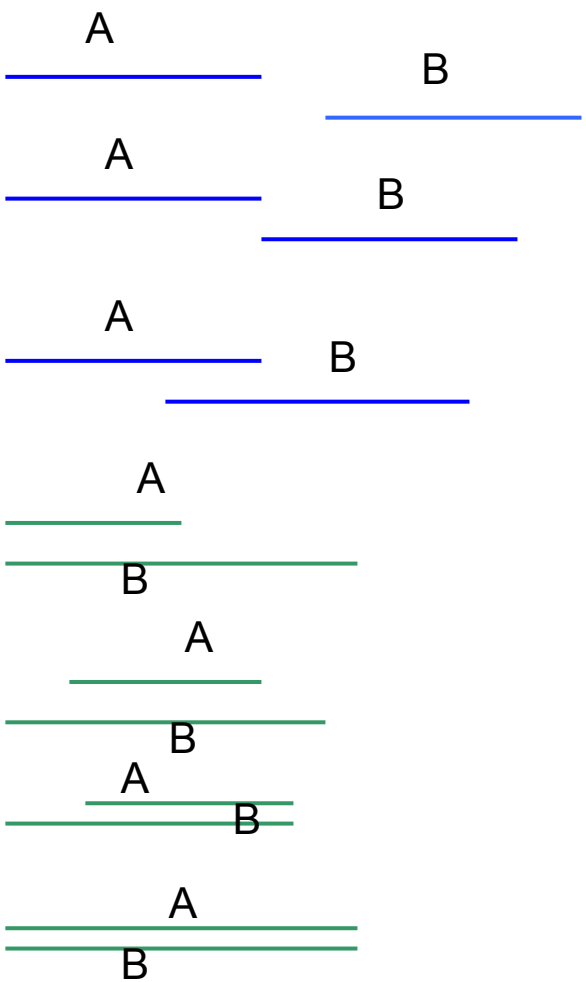
Topics today

- Allen‘s interval algebra
- STRIPS planning
  - A practical example

Allen‘s interval algebra

- Allows computation with time intervals
- 13 basic relations between intervals
- Properties hold during a whole interval
- Algebra:
  - Relations can be combined without leaving the set of possible relations

Allen's 13 basic relations



A before (b) B B after (a) A

A meets (m) B B met-by (mi) A

A overlaps (o) B B overlapped-by (oi) A

A starts (s) B B started-by (si) A

A during (d) B B during-inverse (di) A

A finishes (f) B B finished-by (fi) A

A equals (eq) B

Reasoning with interval relations:

A r1 B

B r2 C

A ??? C

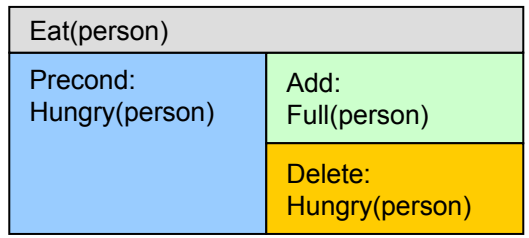
B r2 C / A r1 B	<	>	d	di	o	oi	m	mi	s	si	f	fi
"before" <	<	no info	< o m d s	<	<	< o m d s	<	< o m d s	<	<	< o m d s	<
"after" >	no info	>	> oi mi d f	>	> oi mi d f	>	> oi mi d f	>	> oi mi d f	>	>	>
"during" d	<	>	d	no info	< o m d s	> oi mi d f	<	>	d	> oi mi d f	d	< o m d s
"contains" di	< o m di fi	> oi di mi si	o oi dur con =	di	o di fi	oi di si	o di fi	oi di si	di fi o	di	di si oi	di
"overlaps" o	<	> oi di mi si	o d s	< o m di fi	< o m	o oi dur con =	<	oi di si	o	di fi o	d s o	< o m
"over-lapped-by" oi	< o m di fi	>	oi d f	> oi mi di si	o oi dur con =	> oi mi	o di fi	>	oi d f	oi > mi	oi	oi di si
"meets" m	<	> oi mi di si	o d s	<	<	o d s	<	f fi =	m	m	d s o	<
"met-by" mi	< o m di fi	>	oi d f	>	oi d f	>	s si =	>	d f oi	>	mi	mi
"starts" s	<	>	d	< o m di fi	< o m	oi d f	<	mi	s	s si =	d	< m o
"started by" si	< o m di fi	>	oi d f	di	o di fi	oi	o di fi	mi	s si =	si	oi	di
"finishes" f	<	>	d	> oi mi di si	o d s	> oi mi	m	>	d	> oi mi	f	f fi =
"finished-by" fi	<	> oi mi di si	o d s	di	o	oi di si	m	si oi di	o	di	f fi =	fi

STRIPS Stanford Research Institute Problem Solver (1972)

- Given a state and an action:
  - Can the action be executed?
  - What propositions are (in)valid after the action?
- Closed world assumption:
  - We know all true statements
  - All unknown statements are false
- Description of initial state and goal state
  - Sets of positive facts
- Set of STRIPS-operators with 3 parts:
  - Preconditions: what needs to hold, such that the op. can be ex.?
  - Add list: what holds after the op. is ex.?
  - Delete list: what doesn't hold after the op. is ex.?
- Planning problem: how to get from initial to goal state

Example STRIPS operator

- Operator name: Eat
  - Parameter: a person



- Can only be applied if person is hungry
- Removes the fact that person is hungry
- Adds the fact that person is full

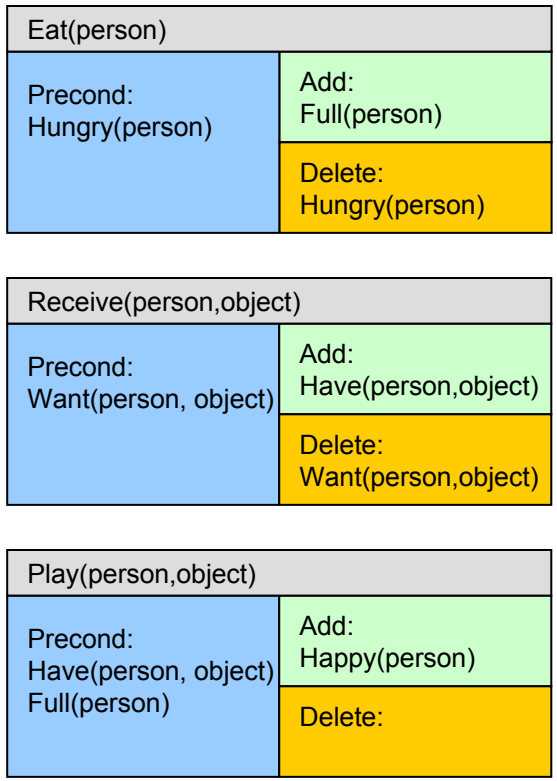
- Remember: only positive facts!

Christmas evening

- Initial state
  - Hungry(children)
  - Want(children,gifts)
- Goal state
  - Happy(children)

Christmas Eve: Dysfunctional Family

- Initial state
  - Hungry(children)
  - Want(children,gifts)
- Goal state
  - Happy(children)



- How do we get from initial to goal state?

Dysfunctional Family: Solutions

Eat(person)	
Precond: Hungry(person)	Add: Full(person)
	Delete: Hungry(person)

Receive(person,object)	
Precond: Want(person, object)	Add: Have(person,object)
	Delete: Want(person,object)

play(person,object)	
Precond: Have(person, object) Full(person)	Add: Happy(person)
	Delete:

- Eat(children)
- Receive(children,gifts)
- Play(children,gifts)

or

- Receive(children,gifts)
- Eat(children)
- Play(children,gifts)

- Note:
  - Unknown facts are false
  - True facts remain true
  - Planning strategy?

- In this case:
  - Order of eat/gifts doesn‘t matter
  - Order of eat/play matters
  - Parents aren‘t happy
  - Parents don‘t eat
  - Parents don‘t play
  - …??

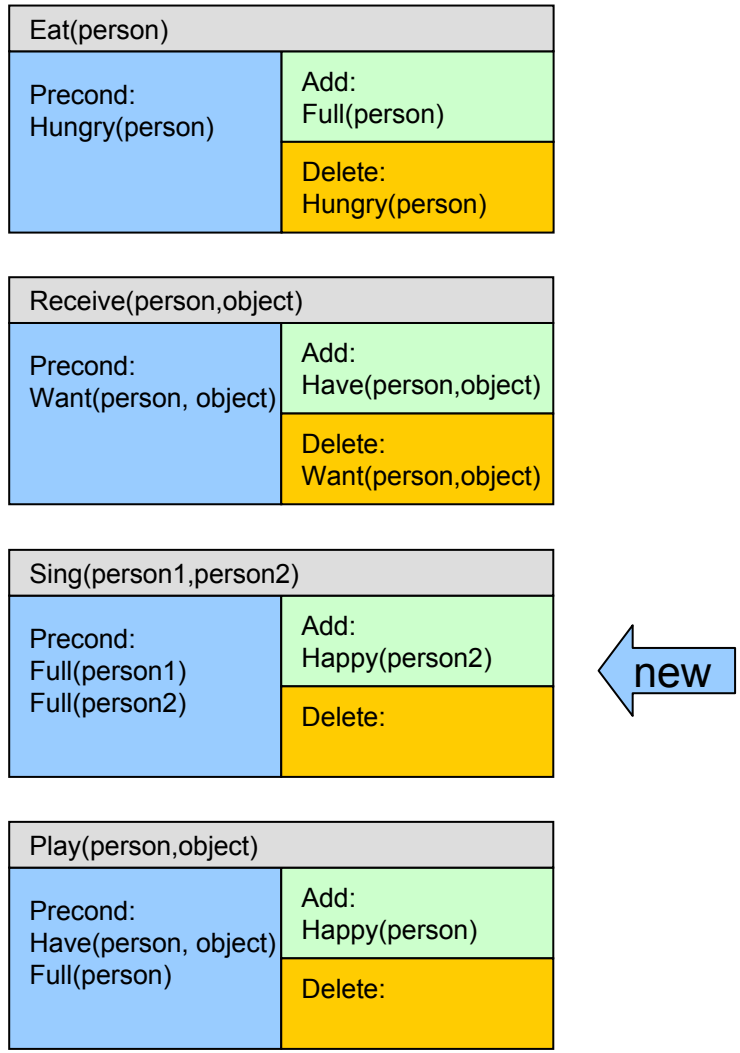
Christmas evening (2nd try)

- Initial state
  - Hungry(children)
  - Hungry(parents)
  - Want(children,gifts)

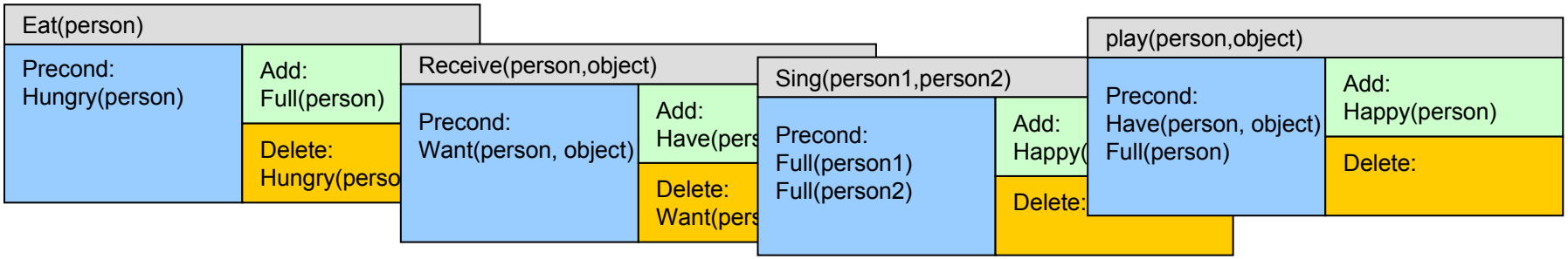
- Goal state
  - Happy(children)
  - Happy(parents)

Christmas Eve: Musical Family

- Initial state
  - Hungry(children)
  - Hungry(parents)
  - Want(children,gifts)
- Goal state
  - Happy(children)
  - Happy(parents)



Musical Family: Solutions

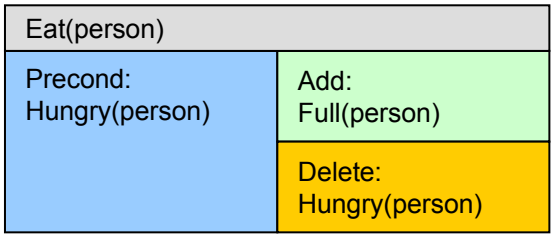


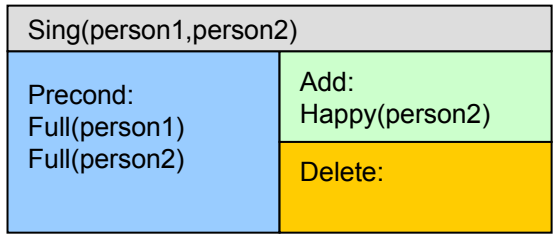
- Eat(children)
- Eat(parents)
- Sing(children,parents)
- Receive(children,gifts)
- Play(children,gifts)

- Only partial order:
  - Children can eat before or after parents
  - Singing can be done before or after gifts
  - All eat before singing

- Planning strategy?

But also this…. 8(





- Eat(children)
- Eat(parents)
- Sing(children,parents)
- Sing(parents,children)

- Not a correct model
  - Children can be happy without gifts
- Even worse:
  - …
  - Sing(parents,children)
  - Receive(parents,gifts)
  - Play(parents,gifts)

Christmas evening (3rd try)

- Initial state
  - Hungry(children)
  - Hungry(parents)
  - Want(children,gifts)
  - In(dad,Lroom)
  - In(children,Lroom)
  - Full(santa)

- Goal state
  - Happy(children)
  - Happy(parents)
  - Believe(children,santa)

Plan your own Christmas Eve

Enter(person,room)	
Precond: Outs(person,room)	Add: In(person,room)
	Delete: Outs(person,room)

Sing(person1,person2)	
Precond: Full(person1) Full(person2) Want(person1,gifts)	Add: Happy(person2)
	Delete:

Leave(person,room)	
Precond: In(person,room)	Add: Outs(person,room)
	Delete: In(person,room)

Eat(person)	
Precond: Hungry(person)	Add: Full(person)
	Delete: Hungry(person)

Eat(person)	
Precond: Hungry(person)	Add: Full(person)
	Delete: Hungry(person)

Enter(person,room)	
Precond: Outs(person,room)	Add: In(person,room)
	Delete: Outs(person,room)

Receive(person,object,pers2)	
Precond: Want(person,object) Happy(pers2)	Add: Have(person,object)
	Want(person,object) Happy(pers2)

Change(person1,person2,room)	
Precond: Outs(person1,room) Full(person1)	Outs(person2,room) Full(person2)
	Delete: Outs(person1,room)

Change(person1,person2,room)	
Precond: Outs(person1,room) Full(person1)	Outs(person2,room) Full(person2)
	Delete: Outs(person1,room)

Sing(person1,person2)	
Precond: Full(person1) Full(person2) Want(person1,gifts)	Add: Happy(person2)
	Delete:

Leave(person,room)	
Precond: In(person,room)	Add: Outs(person,room)
	Delete: In(person,room)

See(person1,person2,room)	
Precond: in(pers1,room) In(pers2,room)	Add: Believe(pers1,pers2)
	Delete:

Play(person,object)	
Precond: Have(person, object) Full(person)	Add: Happy(person)
	Delete:

STRIPS backward planning

- Choose one fact from goal state
- See how it can be achieved
  - Fact is in the add list of operator
  - No other fact from goal state is in delete list
- Remove fact from goal, add preconditions
- Iterate until all goal facts are known to be true
- Backtrack if no choice is possible

- Good choice in step 1: fewer preconditions

Christmas Eve: Family with small children

- Eat(children)
- Eat(parents)
- Sing(children,parents)
- Leave(dad,Lroom)
- Change(dad,santa)
- Enter(santa,Lroom)
- See(children,santa)
- Sing(children,santa)
- Receive(children,gifts, santa)
- Leave(santa,Lroom)
- Change(santa,dad)
- Enter(dad,Lroom)
- Play(children,gifts)

Leave(person,room)	
Precond: In(person,room)	Add: Outs(person,room) Delete: In(person,room)

Eat(person)	
Precond: Hungry(person)	Add: Full(person) Delete: Hungry(person)

Enter(person,room)	
Precond: Outs(person,room)	Add: In(person,room) Delete: Outs(person,room)

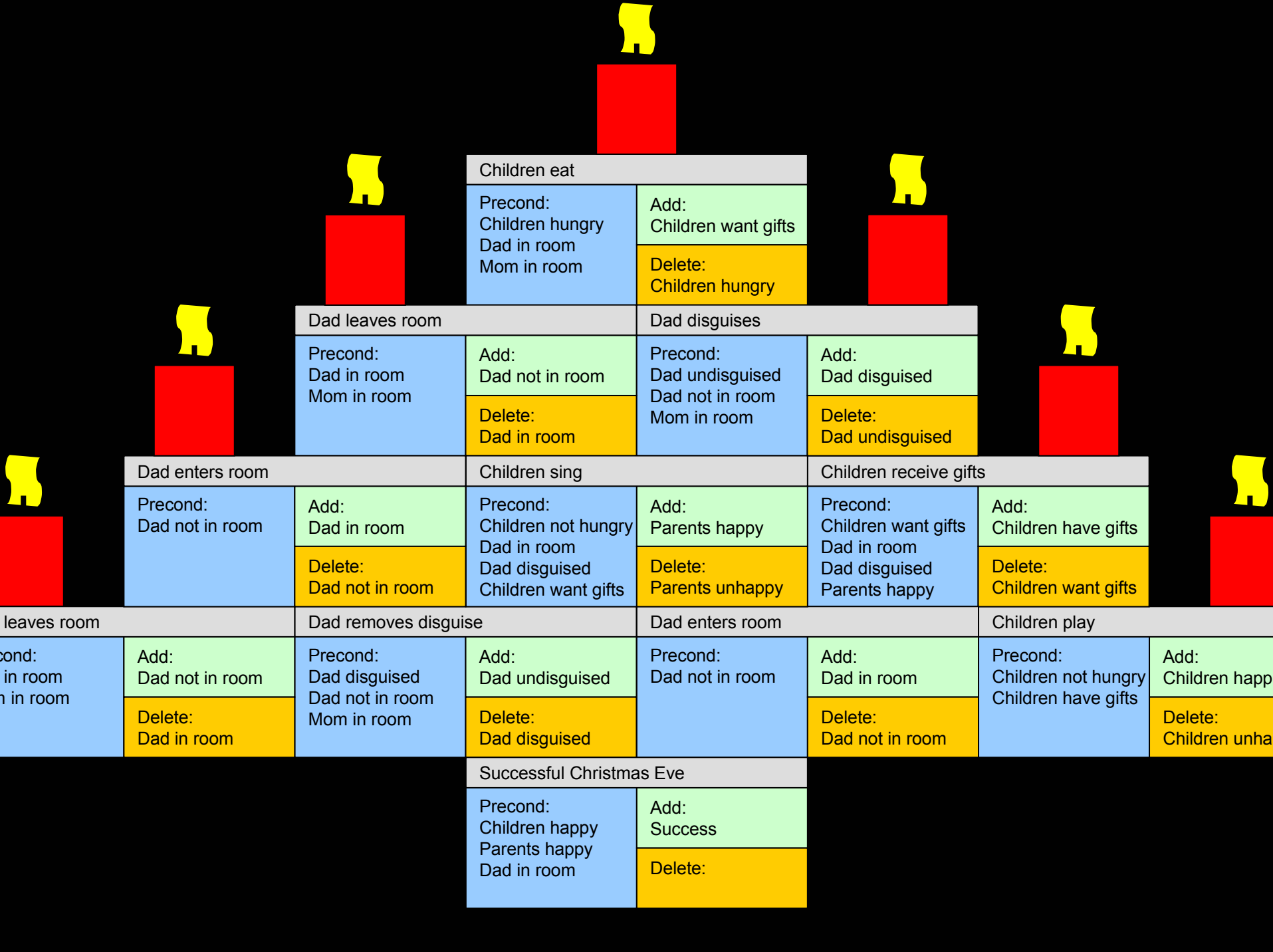
Receive(person,object,pers2)	
Precond: Want(person,object) Happy(pers2)	Add: Have(person,object) Want(person,object) Happy(pers2)

Change(person1,person2,room)	
Precond: Outs(person1,room) Full(person1)	Outs(person2,room) Full(person2) Delete: Outs(person1,room)

Sing(person1,person2)	
Precond: Full(person1) Full(person2) Want(person1,gifts)	Add: Happy(person2) Delete:

See(person1,person2,room)	
Precond: in(pers1,room) In(pers2,room)	Add: Believe(pers1,pers2) Delete:

Play(person,object)	
Precond: Have(person, object) Full(person)	Add: Happy(person) Delete:


Children eat
Precond:
Children hungry
Dad in room
Mom in room
Add:
Children want gifts
Delete:
Children hungry
Dad leaves room
Precond:
Dad in room
Mom in room
Add:
Dad not in room
Delete:
Dad in room
Dad disguises
Precond:
Dad undisguised
Dad not in room
Mom in room
Add:
Dad disguised
Delete:
Dad undisguised
Dad enters room
Precond:
Dad not in room
Add:
Dad in room
Delete:
Dad not in room
Children sing
Precond:
Children not hungry
Dad in room
Dad disguised
Children want gifts
Add:
Parents happy
Delete:
Parents unhappy
Children receive gifts
Precond:
Children want gifts
Dad in room
Dad disguised
Parents happy
Add:
Children have gifts
Delete:
Children want gifts
leaves room
cond:
in room
n in room
Add:
Dad not in room
Delete:
Dad in room
Dad removes disguise
Precond:
Dad disguised
Dad not in room
Mom in room
Add:
Dad undisguised
Delete:
Dad disguised
Dad enters room
Precond:
Dad not in room
Add:
Dad in room
Delete:
Dad not in room
Children play
Precond:
Children not hungry
Children have gifts
Add:
Children happ
Delete:
Children unha
Successful Christmas Eve
Precond:
Children happy
Parents happy
Dad in room
Add:
Success
Delete: