Adding Temporal Intention Dynamics to Goal Modeling

Alicia M. Grubb

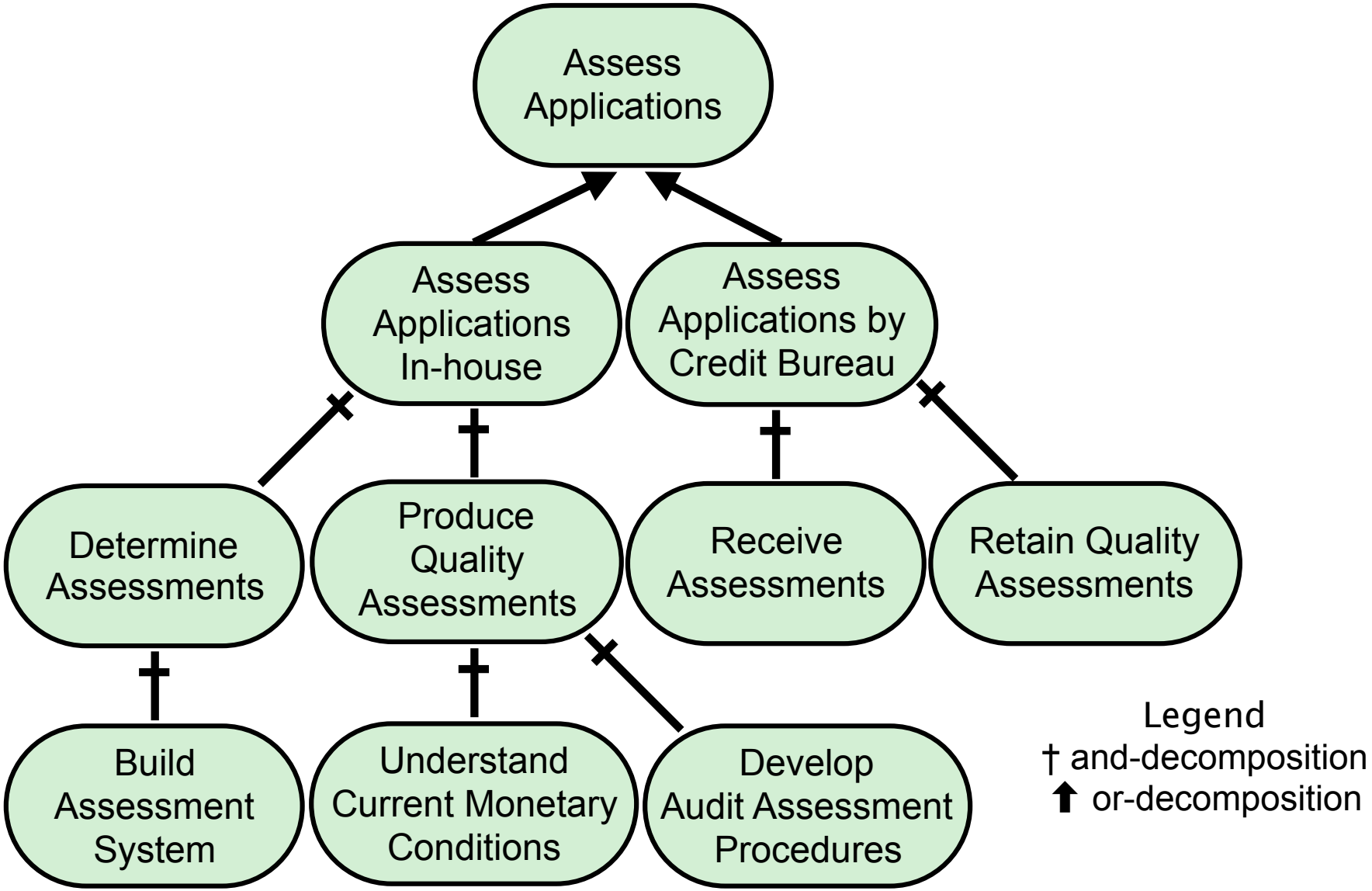
May 2015

Supervised by Marsha Chechik
Department of Computer Science, University of Toronto

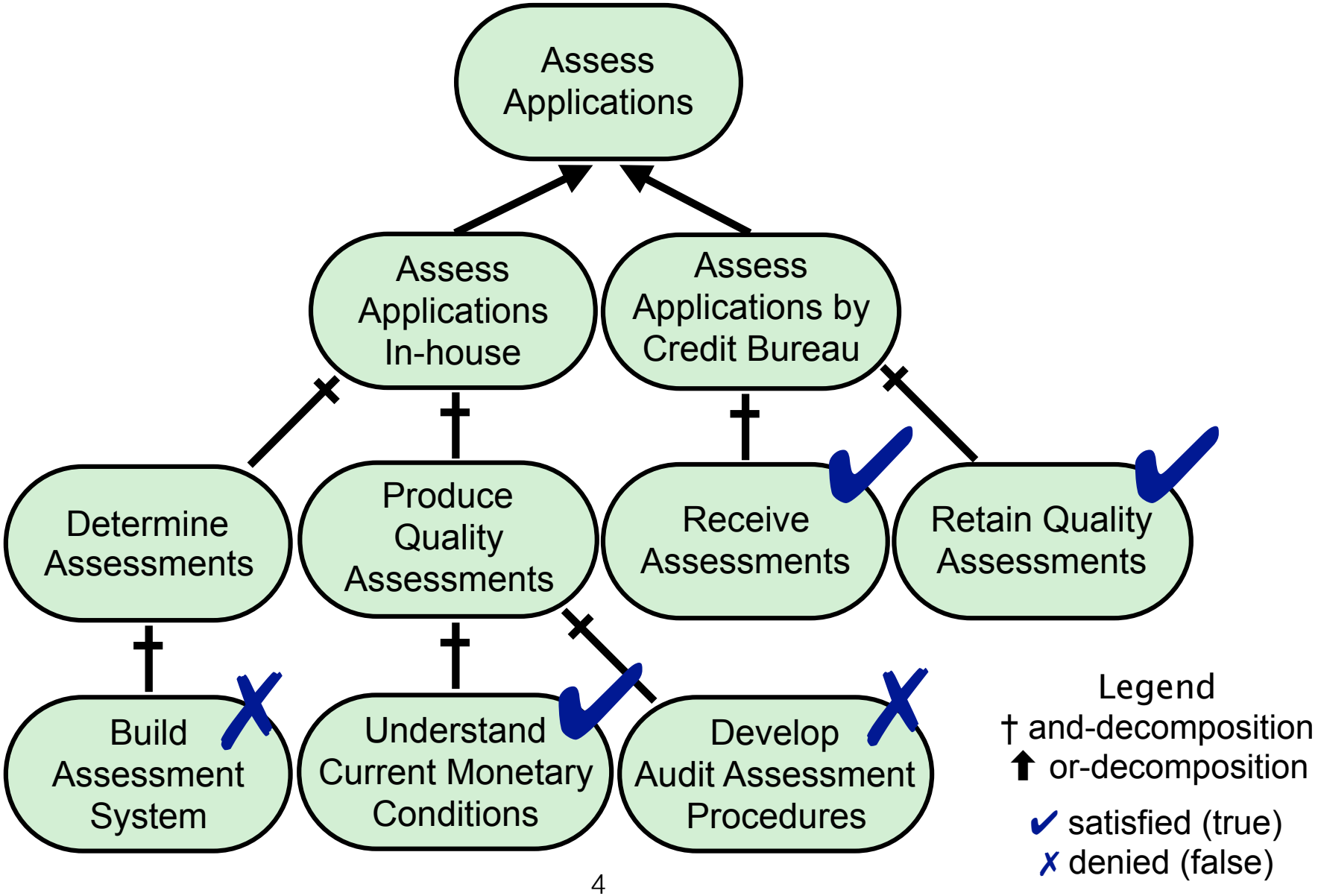
Motivating Example

- Morgan is a working at a bank entering the home loan market.
- Building a system to accept, assess, and manage loans.
- Use goal modeling to evaluate alternatives.
- Decision: *Whether to outsource loan application assessment to a credit bureau to perform in-house.*

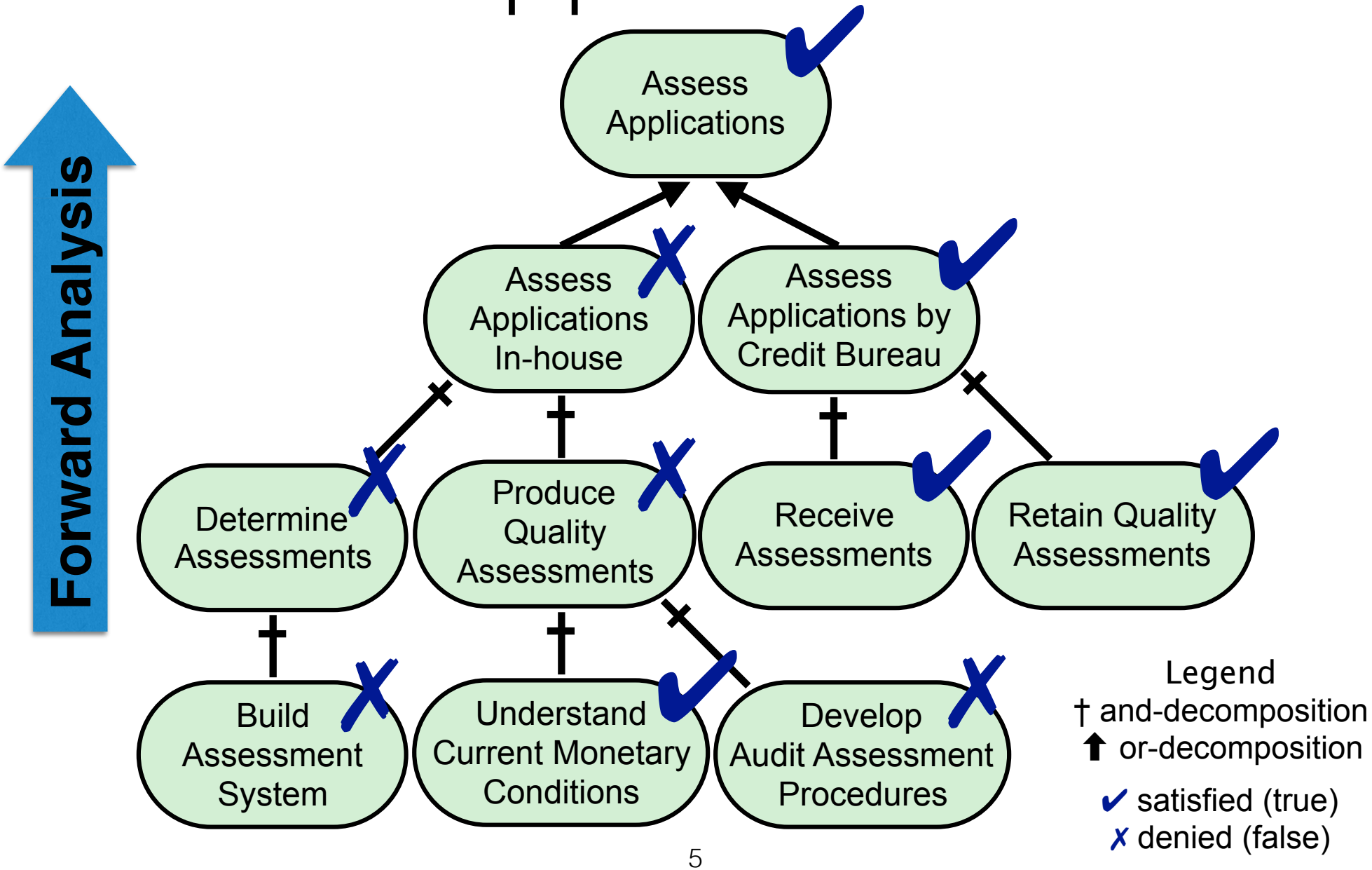
Assess Applications Model



Assess Applications Model

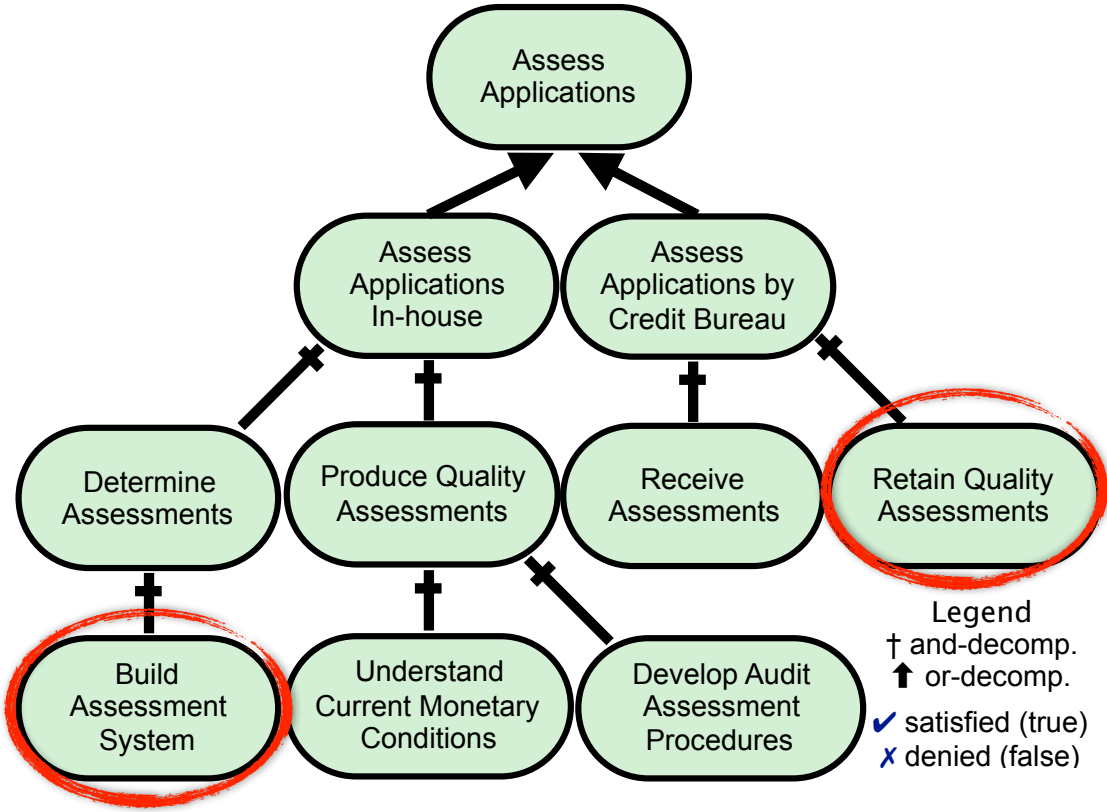


Assess Applications Model



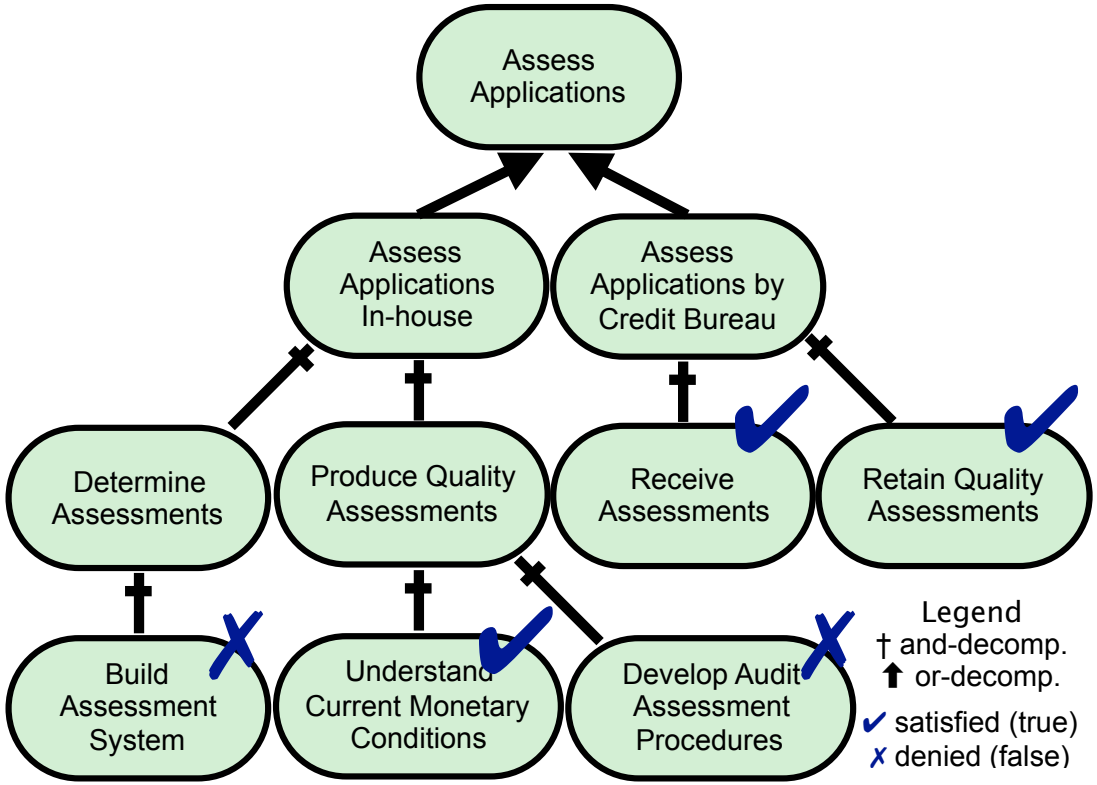
Motivating Example

- A large number of mortgage loans defaulted.
- Morgan returns to the model for clarity.
- Realizes element satisfaction is not how originally assigned.
- New questions arise.



Motivating Example
New Questions

- If the bank built the assessment system would it eventually result in “Assess Applications” being satisfied?
- If “Retain Quality Assessments” Varies over time could “Assess Applications” be satisfied?
- What is the long-term result of choosing the credit bureau?
- What is the best option for the long-term.



Problem

- Early-phase requirements modeling assumes:
  - all model elements have a value
  - model values are constant
- In reality intentions and relationships in the environments are not constant.

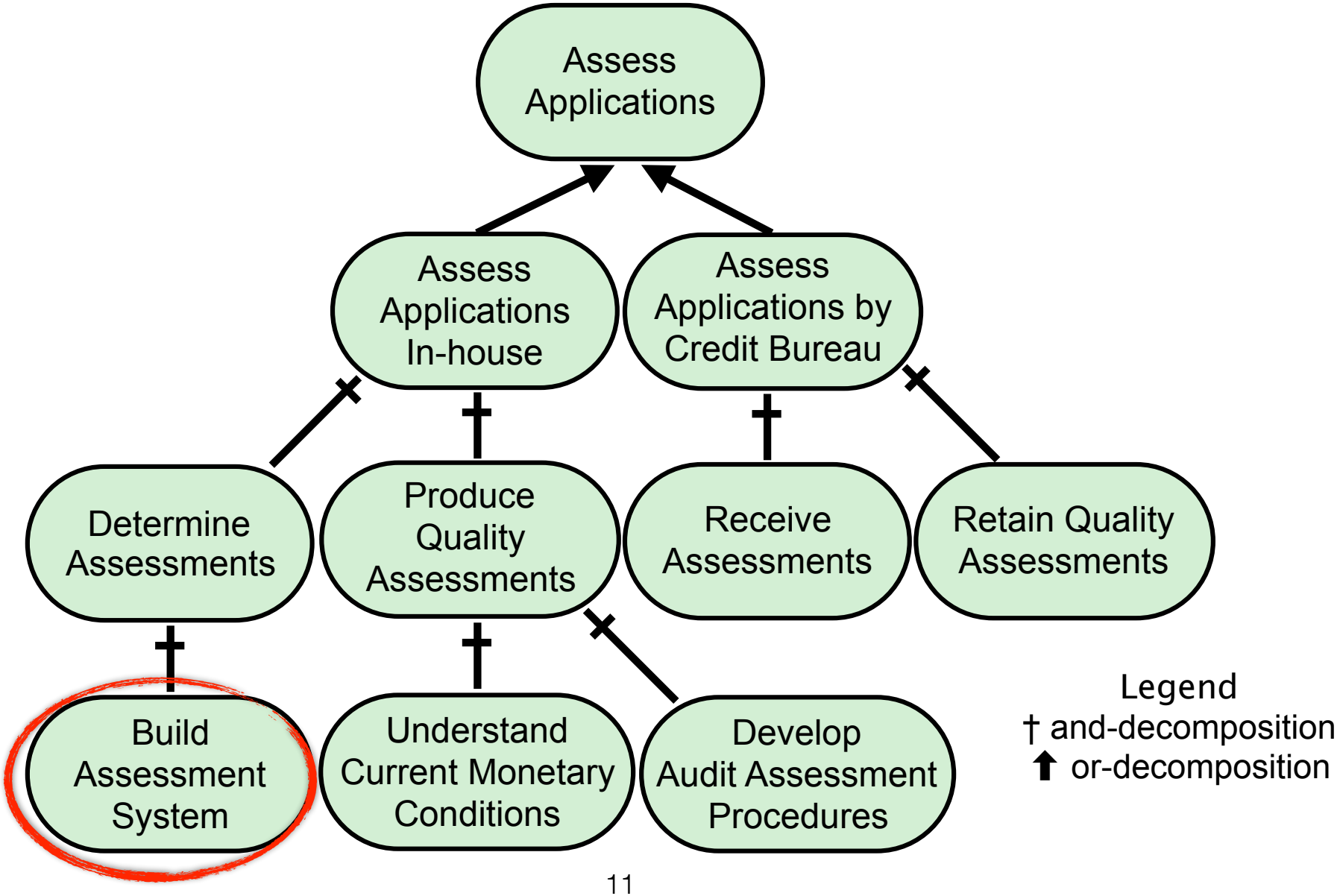
Contributions

- Understand the impacts of dynamically changing intentions on decision making
- Enrich goal models
  - intentions with dynamically changing evaluations
  - temporally delayed dependency relationships

Outline

- Motivating Example - Loan Assessment
- **Modeling Dynamic Intentions**
- Analysis Techniques with Dynamic Intentions
  - Simulation
  - Static Analysis
- Conclusion and Future Directions

Dynamic Intentions



Dynamic Intentions

Set-Stay-Set Positive

Patterns:

Examples:

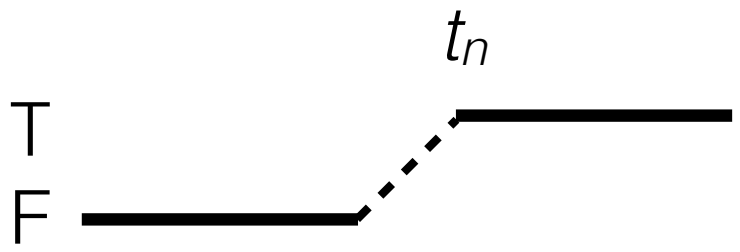
Receive Assessments

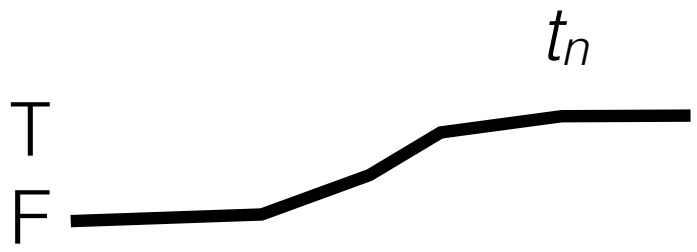
Build Assessment System

Dynamic Intentions

Monotonic Positive

Patterns:





Examples:

Pay off Student Loans

Become Educated

Dynamic Intentions

Stochastic

Patterns:

Examples:

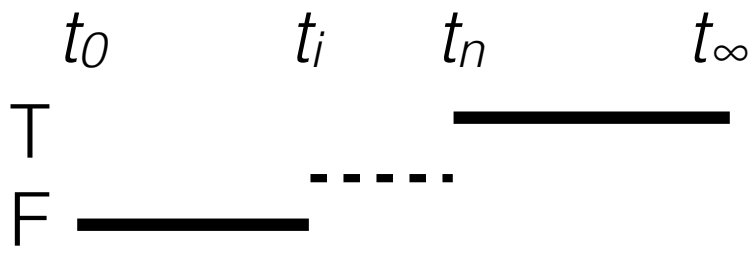
Retain Quality Assessments

Maintain Employment

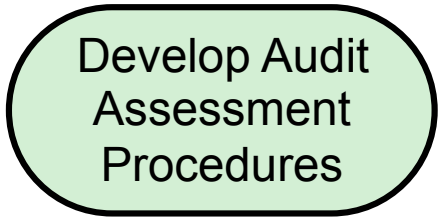
Dynamic Intentions

User Defined

Patterns:



Example:



Dynamic Intentions

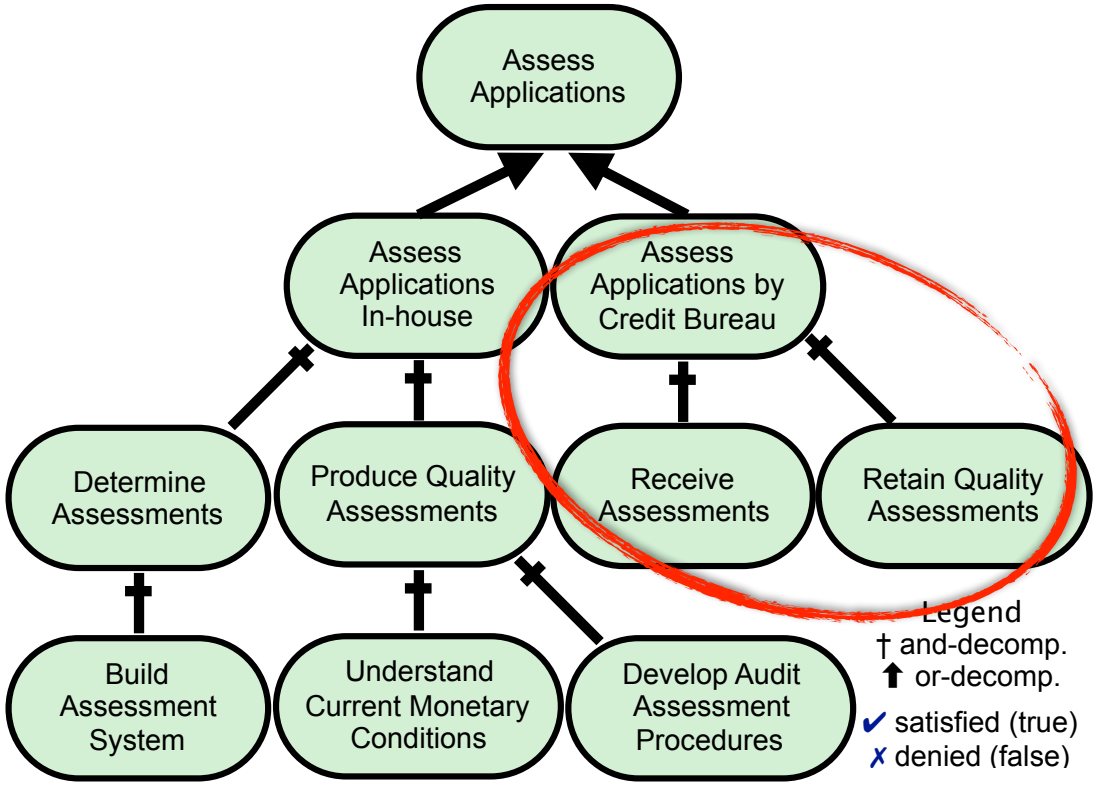
Name	Definition
Set-Stay-Set Positive (SSS+)	stochastically changing until a *static-state* of ✔ (or *true*) is reached
Set-Stay-Set Negative (SSS–)	stochastically changing until a *static-state* of ✗ (or *false*) is reached
Monotonic Positive (M+)	its value will be “more true” or trend toward ✔ (or *true*) as time progresses
Monotonic Negative (M–)	its value will be “less true” or trend toward ✗ (or *false*) as time progresses
Stocastic (RND)	changes in satisfaction level are non-deterministic or random
User Defined	its value is a stepwise function defined by the modeler

Outline

- Motivating Example - Loan Assessment
- Modeling Dynamic Intentions
- **Analysis Techniques with Dynamic Intentions**
  - Simulation
  - Static Analysis
- Conclusion and Future Directions

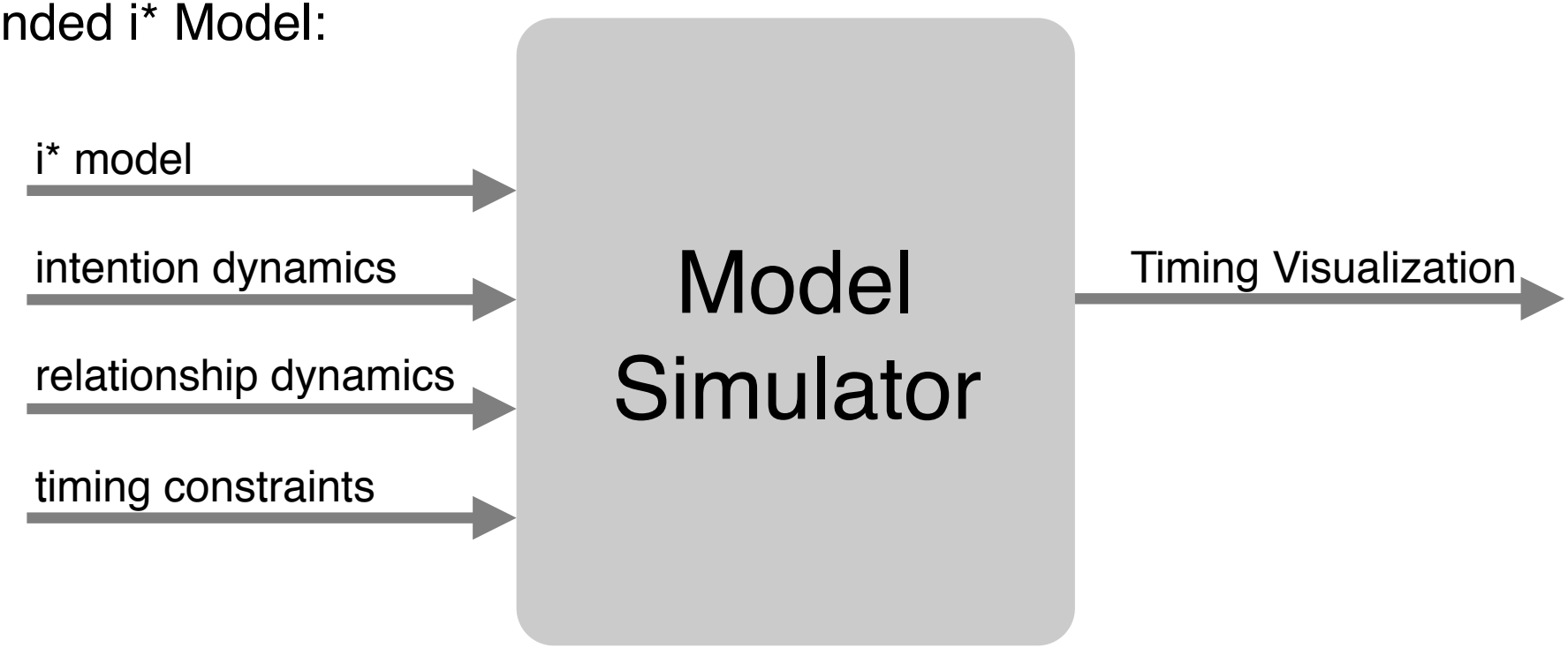
Simulation

- If the bank built the assessment system would it eventually result in “Assess Applications” being satisfied?
- If “Retain Quality Assessments” Varies over time could “Assess Applications” be satisfied?
- What is the long-term result of choosing the credit bureau?
- What is the best option for the long-term.

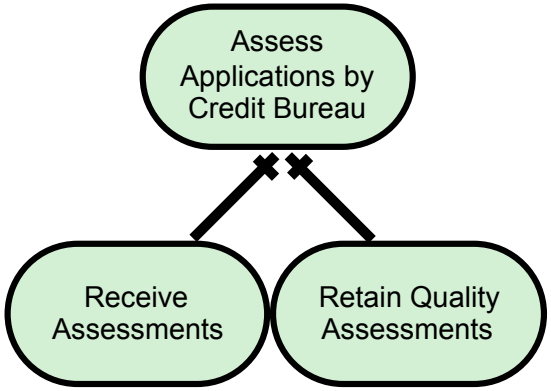


Simulation

Extended i* Model:



Simulation



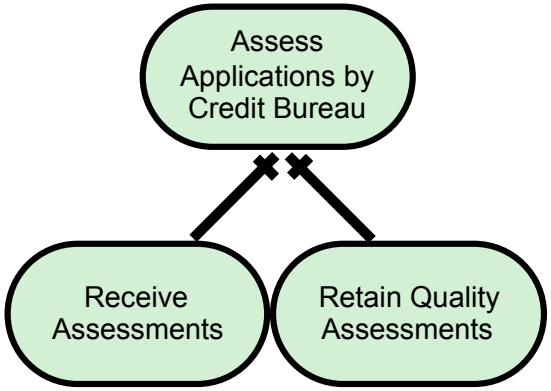
Set-Stay-Set Positive

Stochastic

Inputs (Intentions)	t0	t1	t2
Receive Assessments	T / F		
Receive Quality Assessments	T / F		
Intermediate Nodes	**t0**	**t1**	**t2**
Assessed by Credit Bureau	T / F		

Constraints: Receive Assessment >= Receive Quality Assessment

Simulation



Set-Stay-Set Positive

Stochastic

Inputs (Intentions) t0 t1 t2

Receive Assessments T F

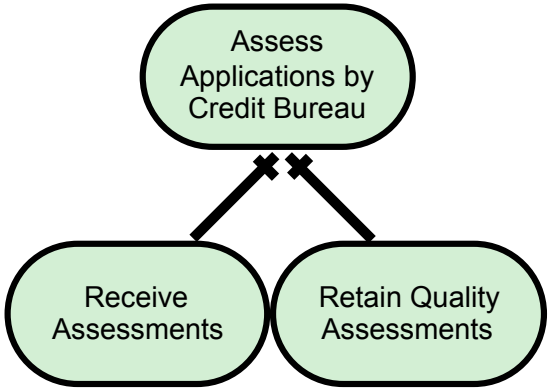
Receive Quality Assessments T F

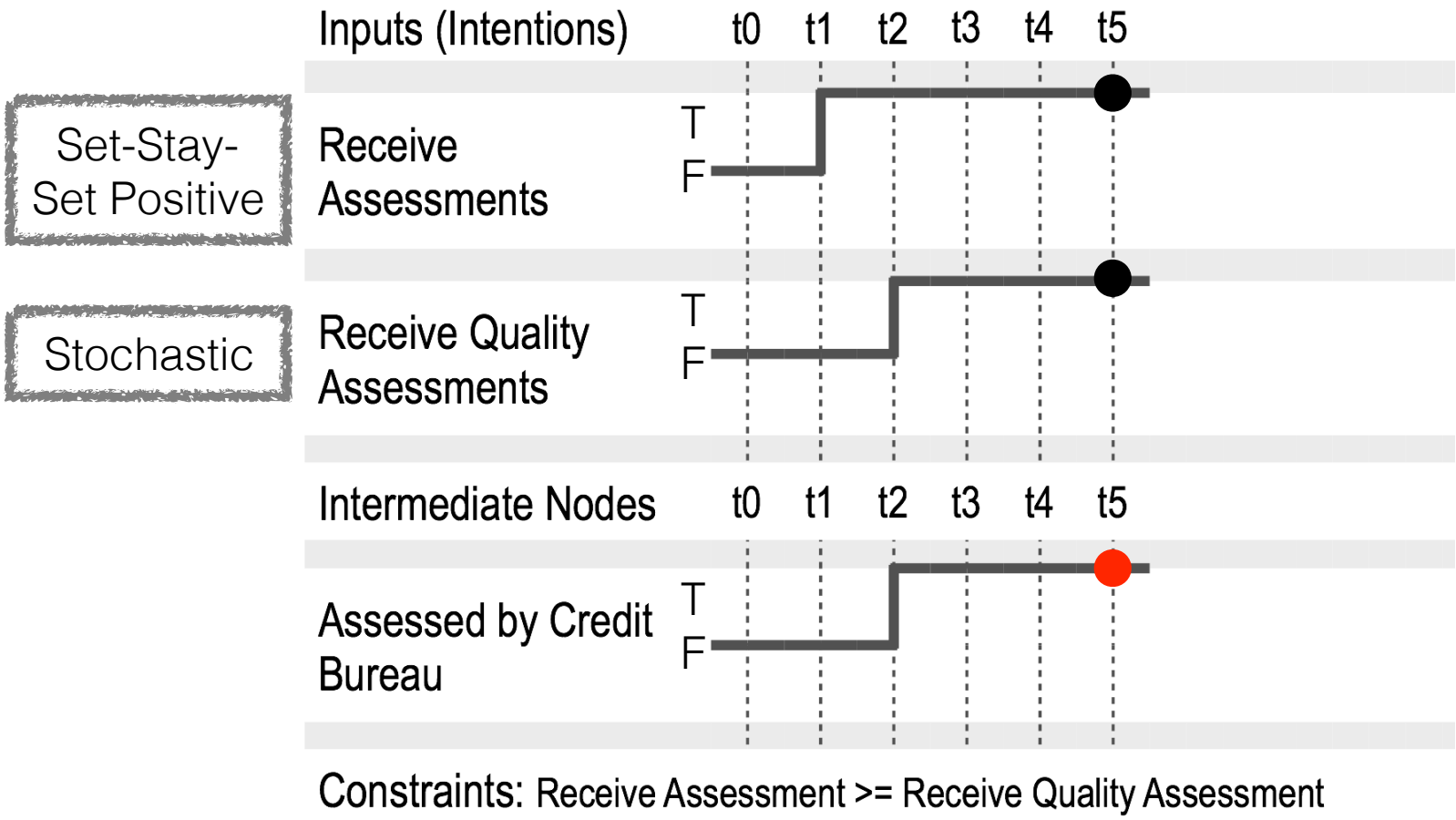
Intermediate Nodes t0 t1 t2

Assessed by Credit Bureau T F

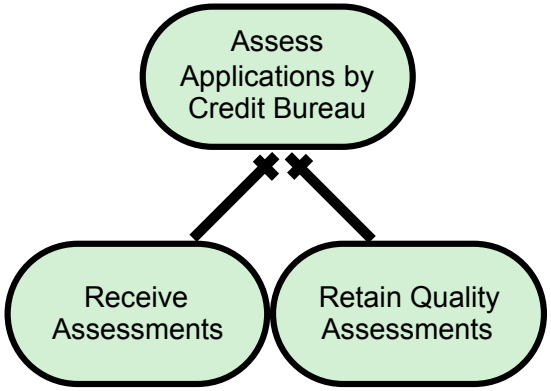
Constraints: Receive Assessment >= Receive Quality Assessment

Simulation



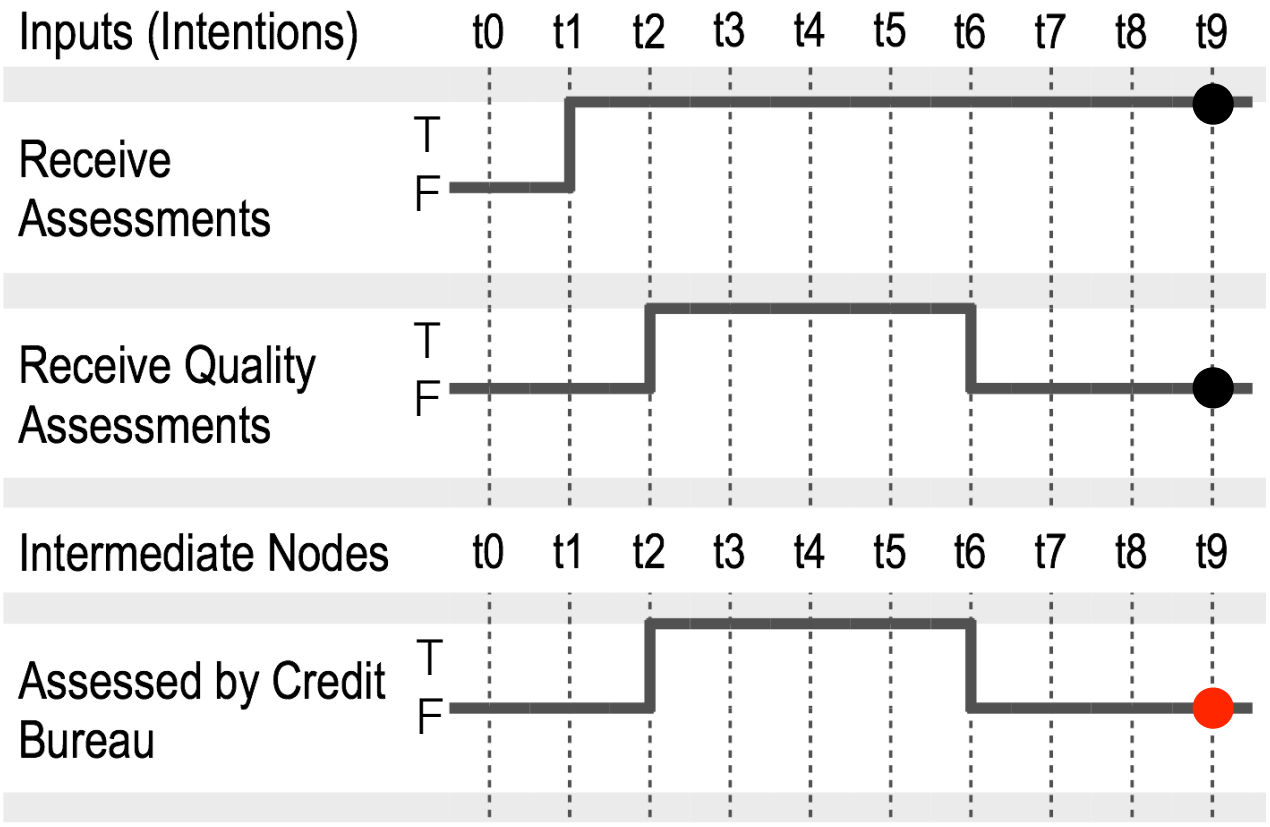


Simulation



Set-Stay-Set Positive

Stochastic



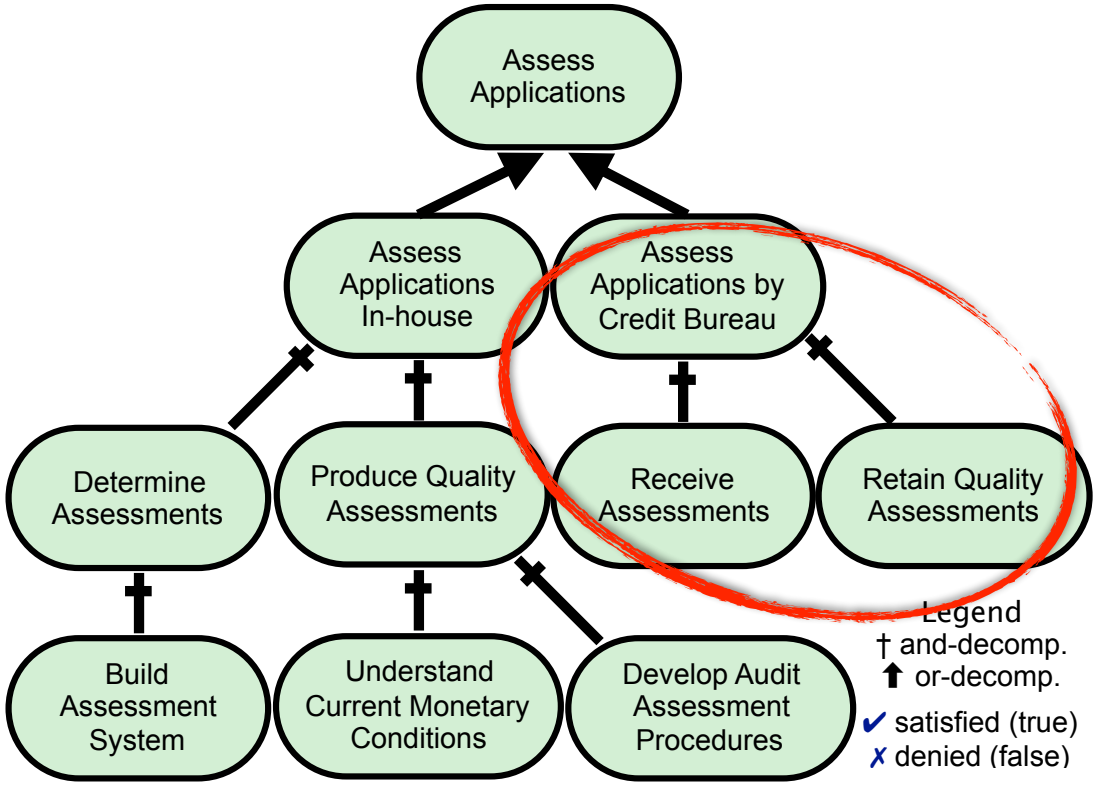
Constraints: Receive Assessment >= Receive Quality Assessment

Simulation

```
Printing IStar Model: Loan Example - Assess Application Sub-model
     Intentions:
     ID    Name  Type  Value
     0     Assess Application    OI    2
     1     Assessed In-house     AI    0
     2     Assessed by Credit Bureau  AI    2
     3     Receive Assessments   MP    2
     4     Receive Quality Assessments      MP    2
     5     Determine AssessmentsNT    0
     6     Build Assessment System    MP    0
     7     Produce Quality Assessments      MP    2
     8     Understand Monetary Conditions   MP    2
     9     Audit Assessments Procedures     MP    0
     Intention Links:
     Name  Type  Source     Target
     -     OR    Assessed In-house     Assess Application
     -     OR    Assessed by Credit Bureau  Assess Application
     -     AND   Receive Assessments   Assessed by Credit Bureau
     -     AND   Receive Quality Assessments      Assessed by Credit Bureau
     -     AND   Determine AssessmentsAssessed In-house
     -     AND   Build Assessment System    Determine Assessments
     -     AND   Produce Quality Assessments      Assessed In-house
     -     MAKE  Understand Monetary Conditions   Produce Quality Assessments
     -     HELP  Audit Assessments Procedures     Produce Quality Assessments

Would you like to (a) interrupt after every Epoch, (b) set a breakpoint,
(w) watch a variable, (v) change a value, (f) run the full simulation?
Performing analysis now:
     ID    0     1     2     3     4     5     6     7     8     9
     TypeOI     AI    AI    MP    MP    NT    MP    MP    MP    MP
      0    2     0     2     2     2     0     0     2     2     0
      1    2     1     2     3     2     1     1     1     2     1
      2    3     1     3     3     3     1     1     2     3     1
      3    3     2     3     3     3     2     2     3     3     2
      4    3     2     3     4     3     2     2     4     4     2
      5    4     2     4     4     4     2     2     4     4     2
Assess by Credit Bureau Satisfied.
Assess Application Satisfied. (Short-term)
     TypeOI     AI    AI    MP    R     NT    MP    MP    MP    MP
          - simulation lines removed for simplicity -
     17   3     3     3     3     2     4     4     3     3     3
     18   3     3     3     4     3     4     4     3     3     3
     19   3     3     1     4     1     4     4     3     3     3
     20   4     4     1     4     1     4     4     4     4     4
Assess by Credit Bureau Satisfied.
Assess Application Satisfied. (Long-term)
     53   4     4     4     4     4     4     4     4     4     4
Finished analysis now. Assess Application Satisfied.
Short-term result recommendation: Assessed by Credit Bureau.
Long-term result recommendation: Assessed In-house.
```

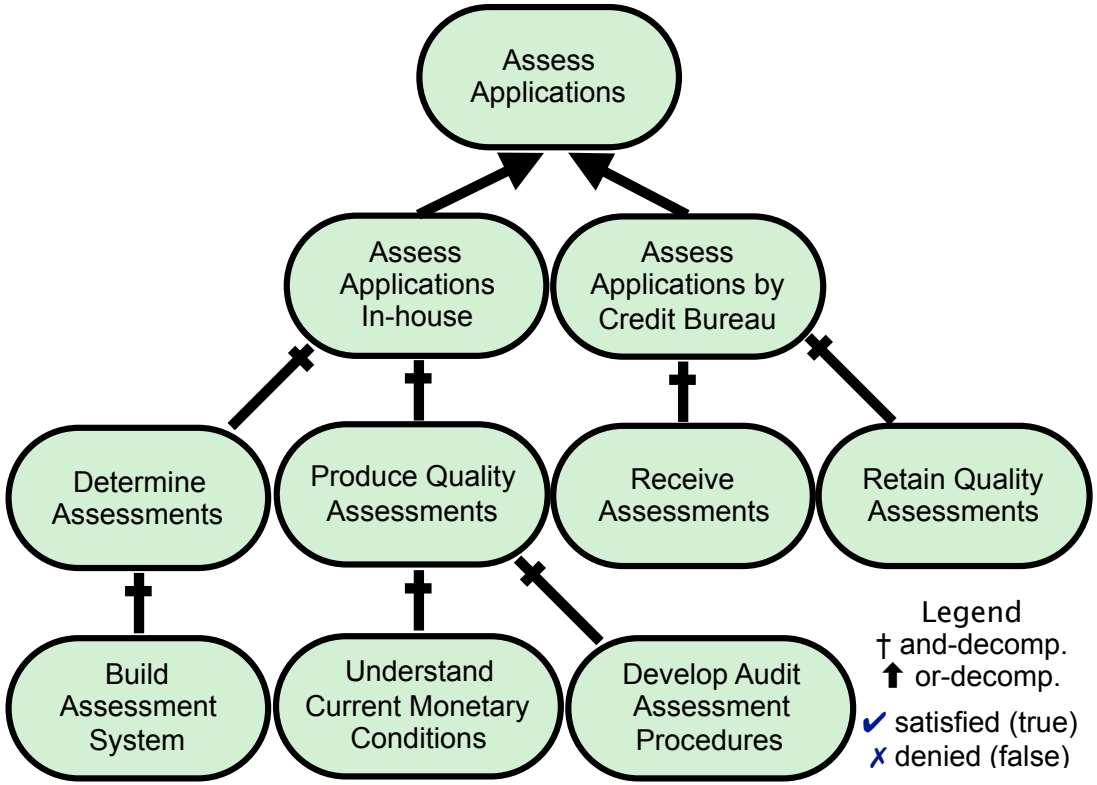
Simulation

- If the bank built the assessment system would it eventually result in “Assess Applications” being satisfied?
- If “Retain Quality Assessments” Varies over time could “Assess Applications” be satisfied?
- What is the long-term result of choosing the credit bureau?
- What is the best option for the long-term.



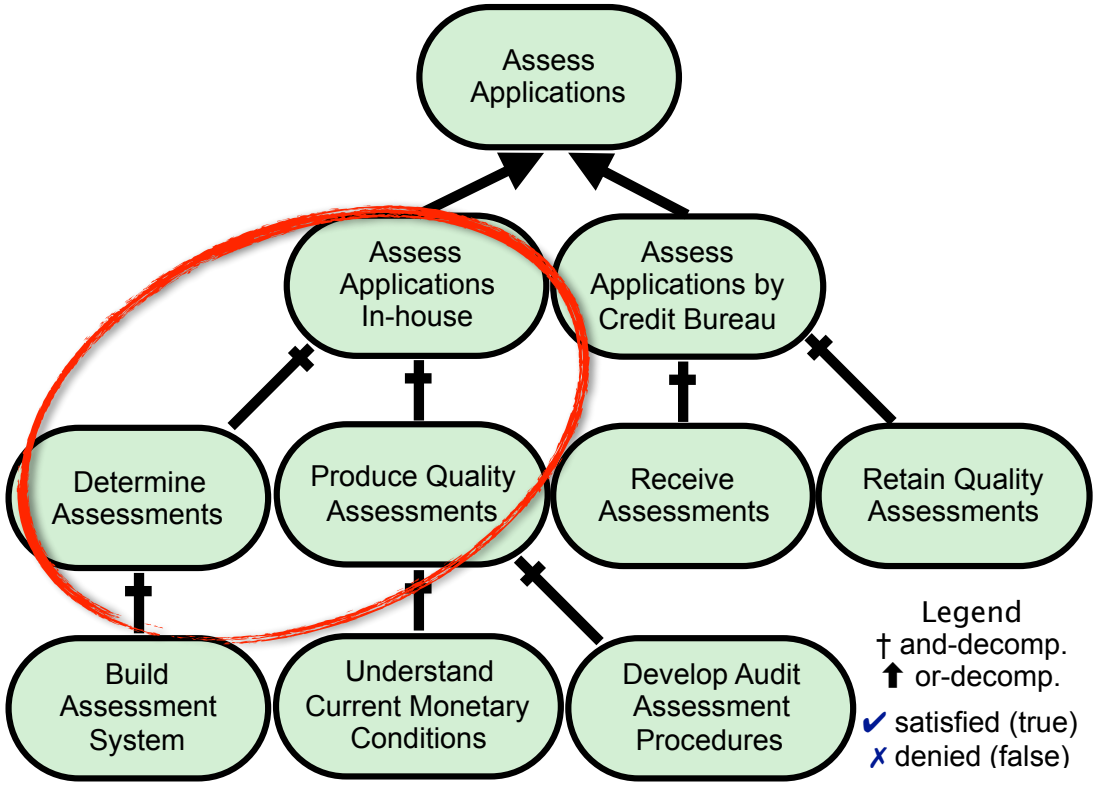
Static Analysis

- Can we make any guarantees about when “Assess Applications by Credit Bureau” will be satisfied?
- Can we make any guarantees about when “Assess In-house” will be satisfied?



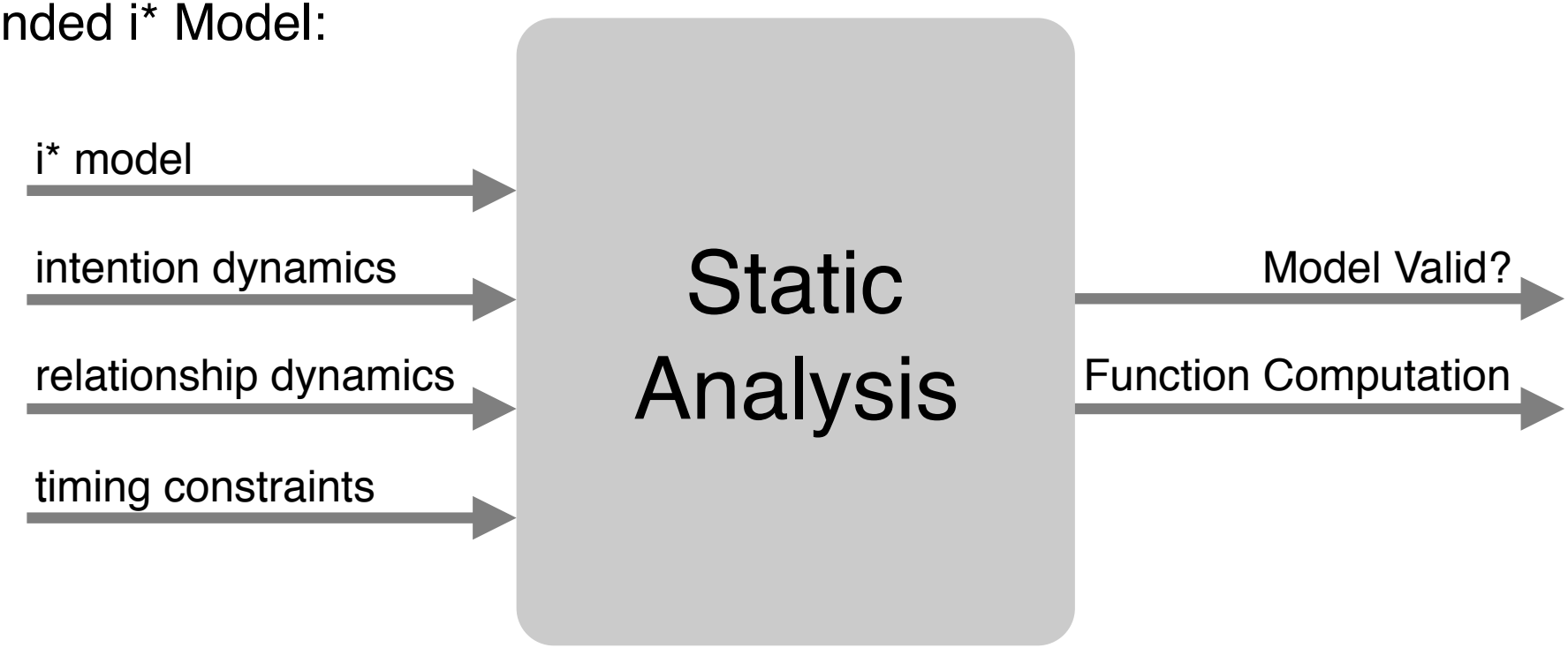
Static Analysis

- Can we make any guarantees about when "Assess Applications by Credit Bureau" will be satisfied?
- Can we make any guarantees about when "Assess In-house" will be satisfied?



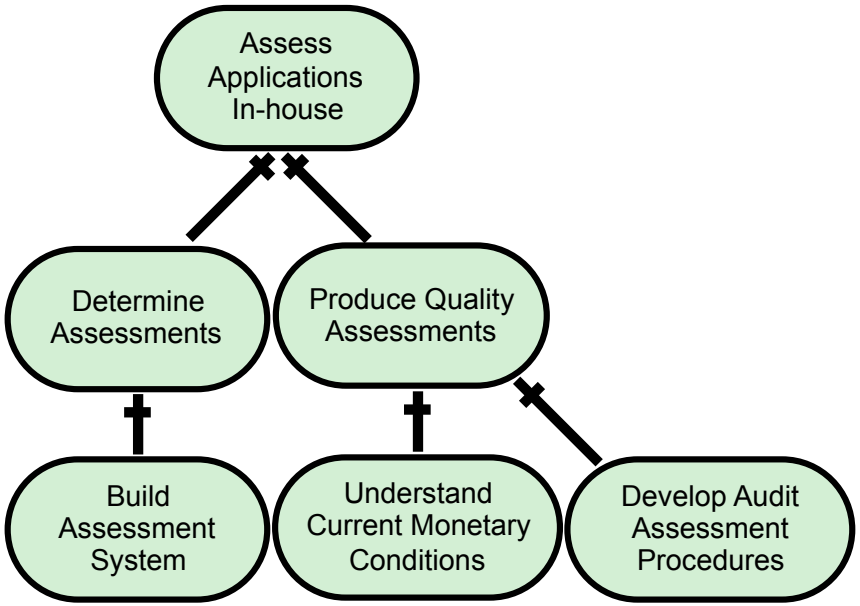
Static Analysis

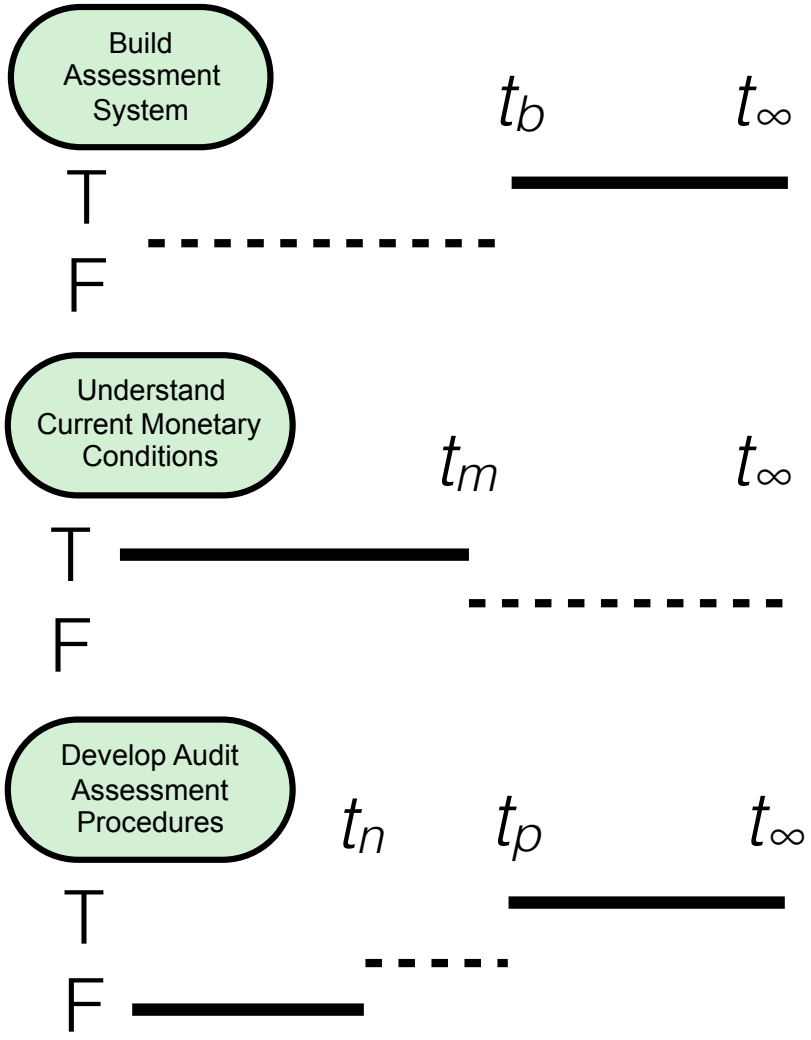
Extended i* Model:



Static Analysis

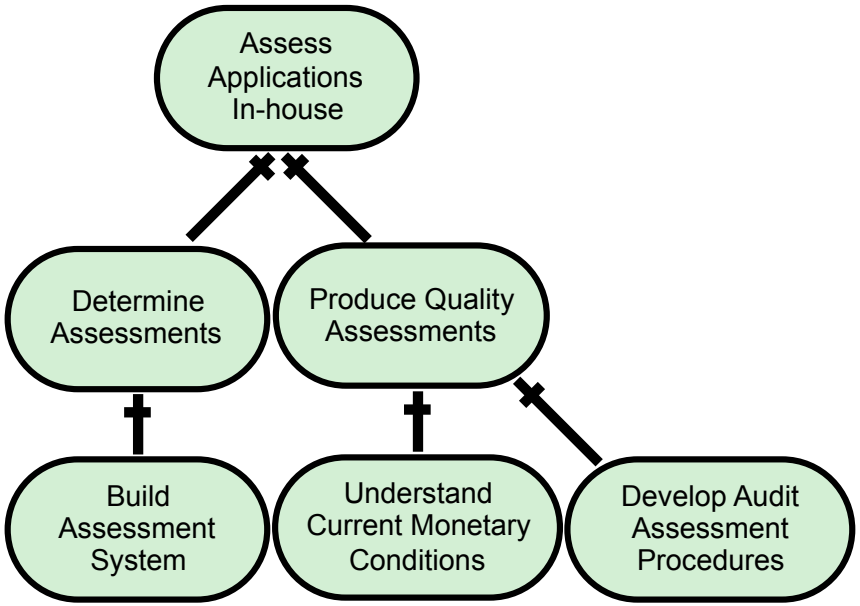
- Question: Can we make any guarantees about when "Assess In-house" will be satisfied.

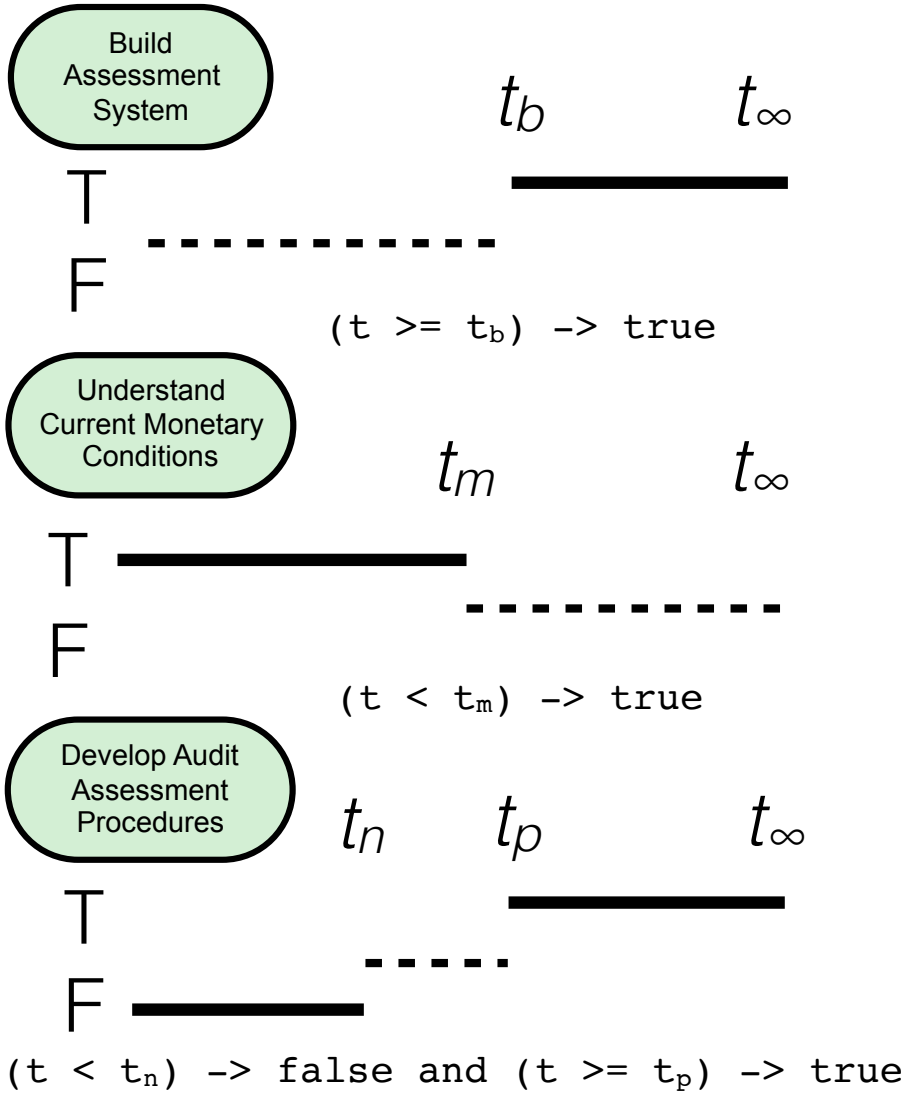




Static Analysis

- Question: Can we make any guarantees about when "Assess In-house" will be satisfied.





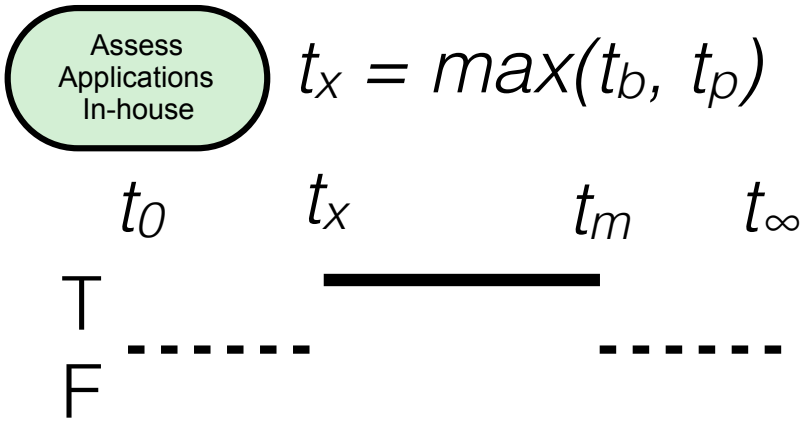
Static Analysis

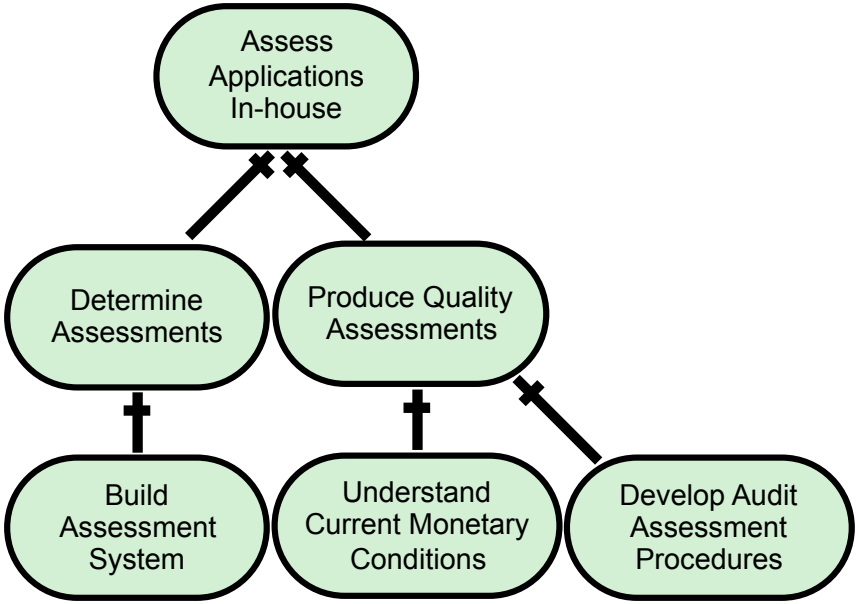
```
(solver
  (< t0 t1 t2 t3 t4 t5 t6 t7 t8 t9 t10)
  (forall ((a Bool) (b Bool)) (= (X a b) (and a b)))
  (forall ((a Bool) (b Bool)) (= (O a b) (or a b)))
  (forall ((a Bool) (b Bool)) (= (M a b) (or a b)))
  (forall ((t Int)) (=> (>= t t4) (C t)))
  (forall ((t Int))
    (and (=> (and (>= t t5) (< t t12)) (D t))
         (=> (and (>= t t0) (< t t3)) (not (D t)))))
  (forall ((t Int)) (= (and (>= t t0) (< t t8)) (E t))))
(X (X (C t) (C t)) (X (D t) (E t)))

The resulting function has the following values:
[ t0 , t3 )
Fully Denied
[ t3 , t4 )
Unknown
[ t4 , t5 )
Unknown
[ t5 , t6 )
Fully Satisfied
[ t6 , t7 )
Fully Satisfied
[ t7 , t8 )
Fully Satisfied
[ t8 , t9 )
Fully Denied
[ t9 , t12 )
Fully Denied
```

Static Analysis

- Question: Can we make any guarantees about when "Assess In-house" will be satisfied.

```
((t >= max(tb, tp)) and
    (t < tm)) -> true
```

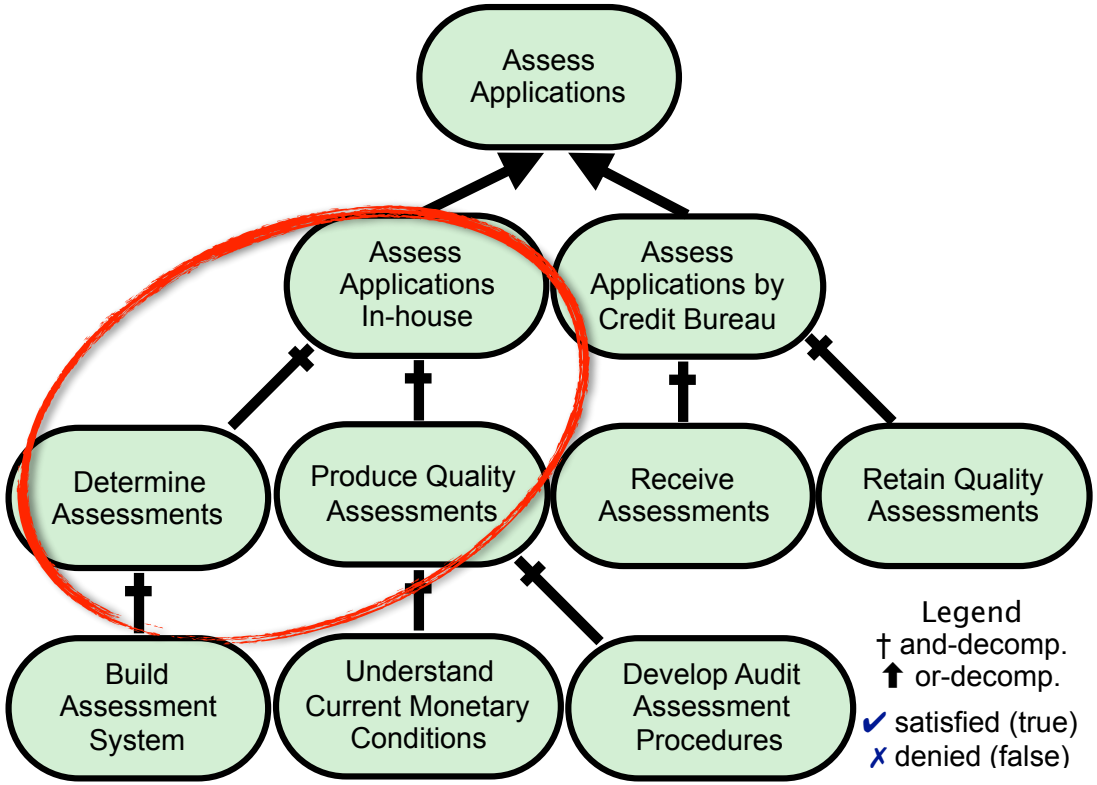




Static Analysis

- Can we make any guarantees about when "Assess Applications by Credit Bureau" will be satisfied?

- ✔ Can we make any guarantees about when "Assess In-house" will be satisfied?



Motivating Example Review

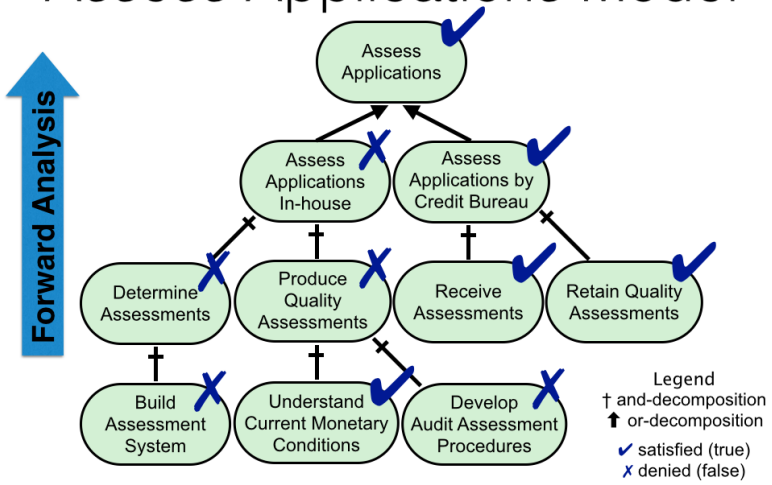
- Morgan is modeling a system to accept, assess, and manage loan applications for a bank entering the home loan market.
- Decision: *Whether to outsource loan application assessment to a credit bureau to perform in-house.*
- Result: Provide additional evidence that enables Morgan to make an improved decision.

Outline

- Motivating Example - Loan Assessment
- Modeling Dynamic Intentions
- Analysis Techniques with Dynamic Intentions
  - Simulation
  - Static Analysis
- **Conclusion and Future Directions**

Summary

Assess Applications Model



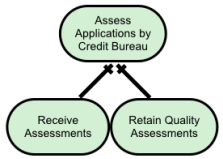
Dynamic Intentions

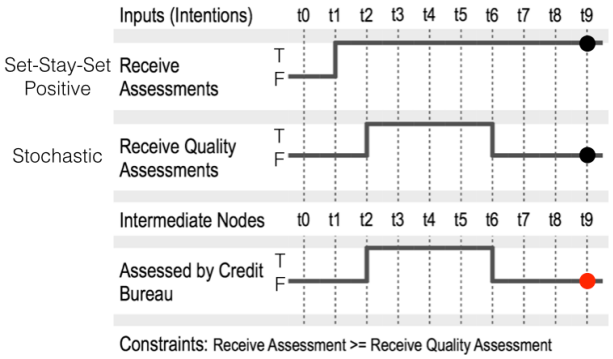
Set-Stay-Set Positive

Patterns:

Examples:

Simulation

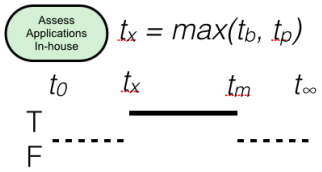


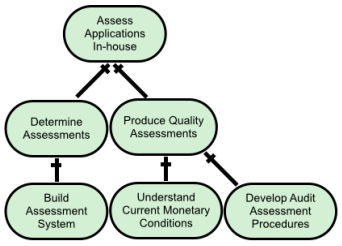


Static Analysis

- Question: Can we make any guarantees about when "Assess In-house" will be satisfied.

```
((t >= max(tb, tp)) and
   (t < tm)) -> true
```





Related Work

- Classifying **goal type** by achievement type.

  [Regev and Wegmann, 2005]

- **Risks** as events that satisfy goal satisfaction.

  [Asnar et al., 2011]

- **Real-time timing** properties as goals.

  [Letier et al., 2002]

- **Temporal ordering** constraints and **simulation** in goal models.

  [Cheong and Winikoff, 2005][Gans et al., 2003]

- Goals as dynamic entities in **runtime goal monitoring** and **adaptive systems**.

  [Robinson, 2005][Bencomo et al., 2010] [Baresi et al., 2010]
  [Vrbaski et al., 2012][Dalpiaz et al., 2013]

- Goal **propagation** algorithms.

  [Chung et al., 2000][Giorgini et al., 2005][van Lamsweerde, 2009]
  [Amyot et al., 2010][Horkoff and Yu, 2014]

Future Work

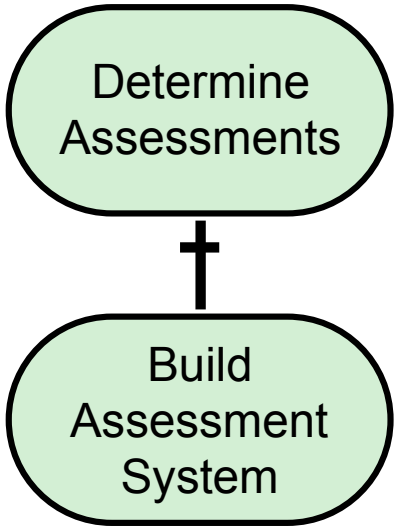
- Developing a tool to enable user studies
- Extend our analysis for:
  - Delayed dependencies
  - Different types of dependencies
- Validation

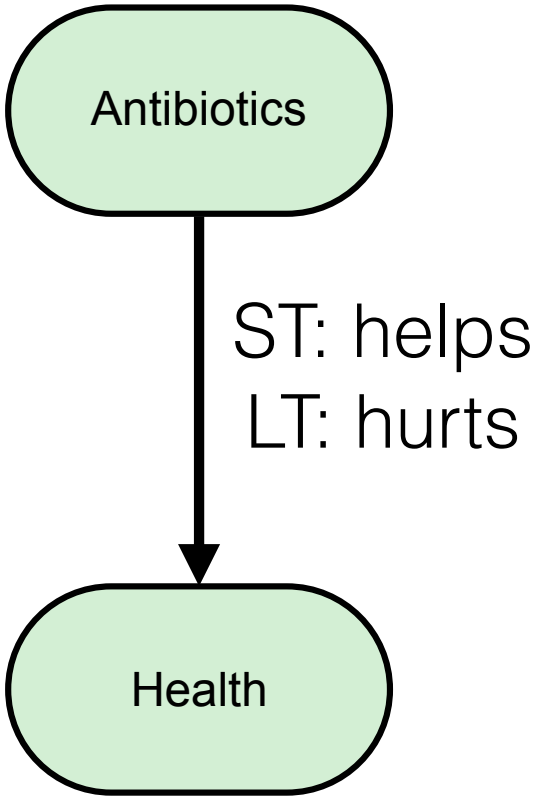
Future Work

- Developing a tool to enable user studies
- Extend our analysis for:
  - **Dynamic Relationships**
  - Different types of dependencies
- Validation

Dynamic Relationships

- Two kinds:
  - Delayed Impact
  - Altered Relationship Type





Questions?

Contributions:

- understand the impacts of dynamically changing intentions on decision making
- enrich goal models
  - intentions with dynamically changing evaluations
  - temporally delayed dependency relationships