Systems Performance Evaluation

Grid Computing (M)

Lecture 19

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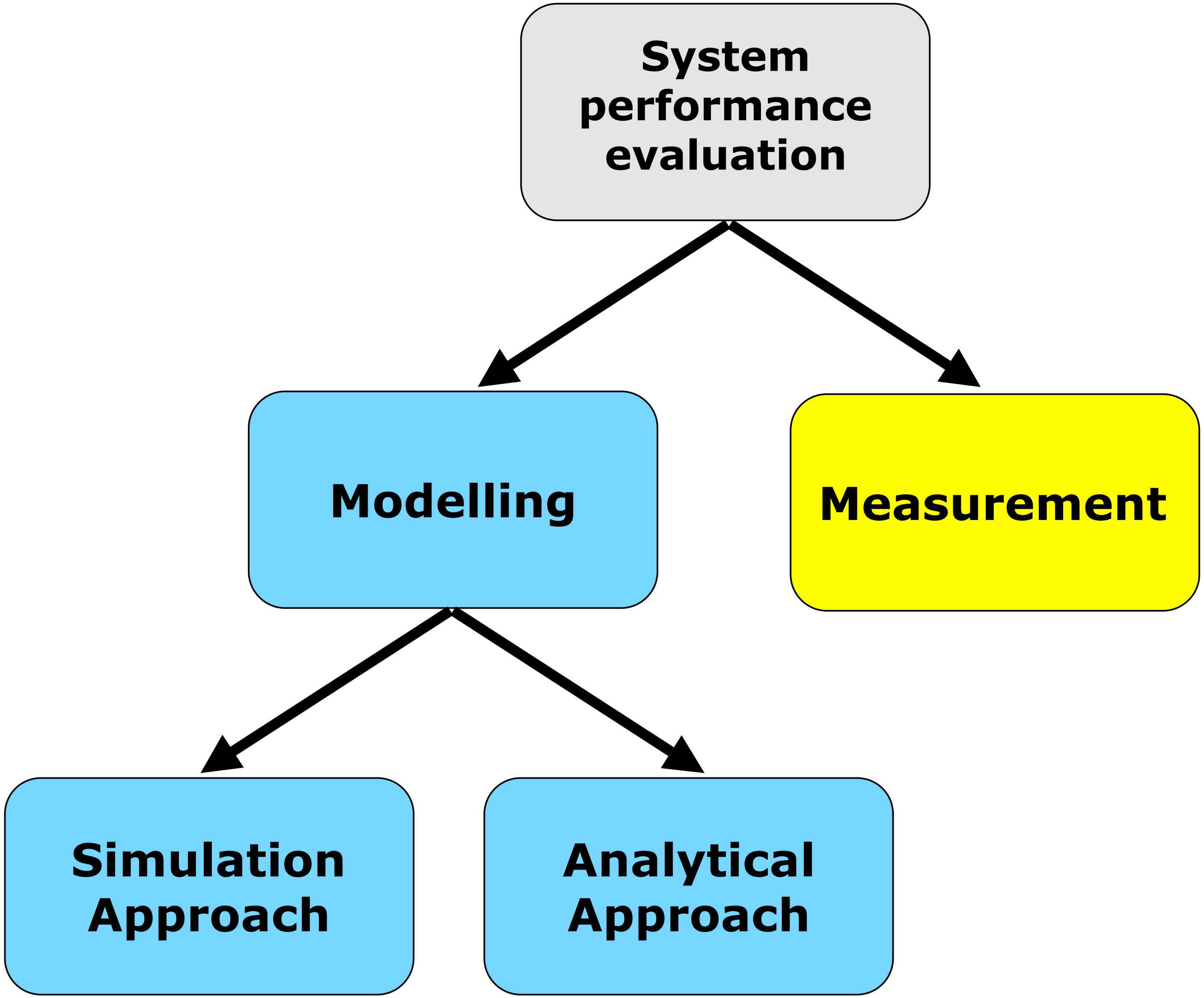
UNIVERSITY of GLASGOW

System Performance Evaluation Choices



Analytical Modelling

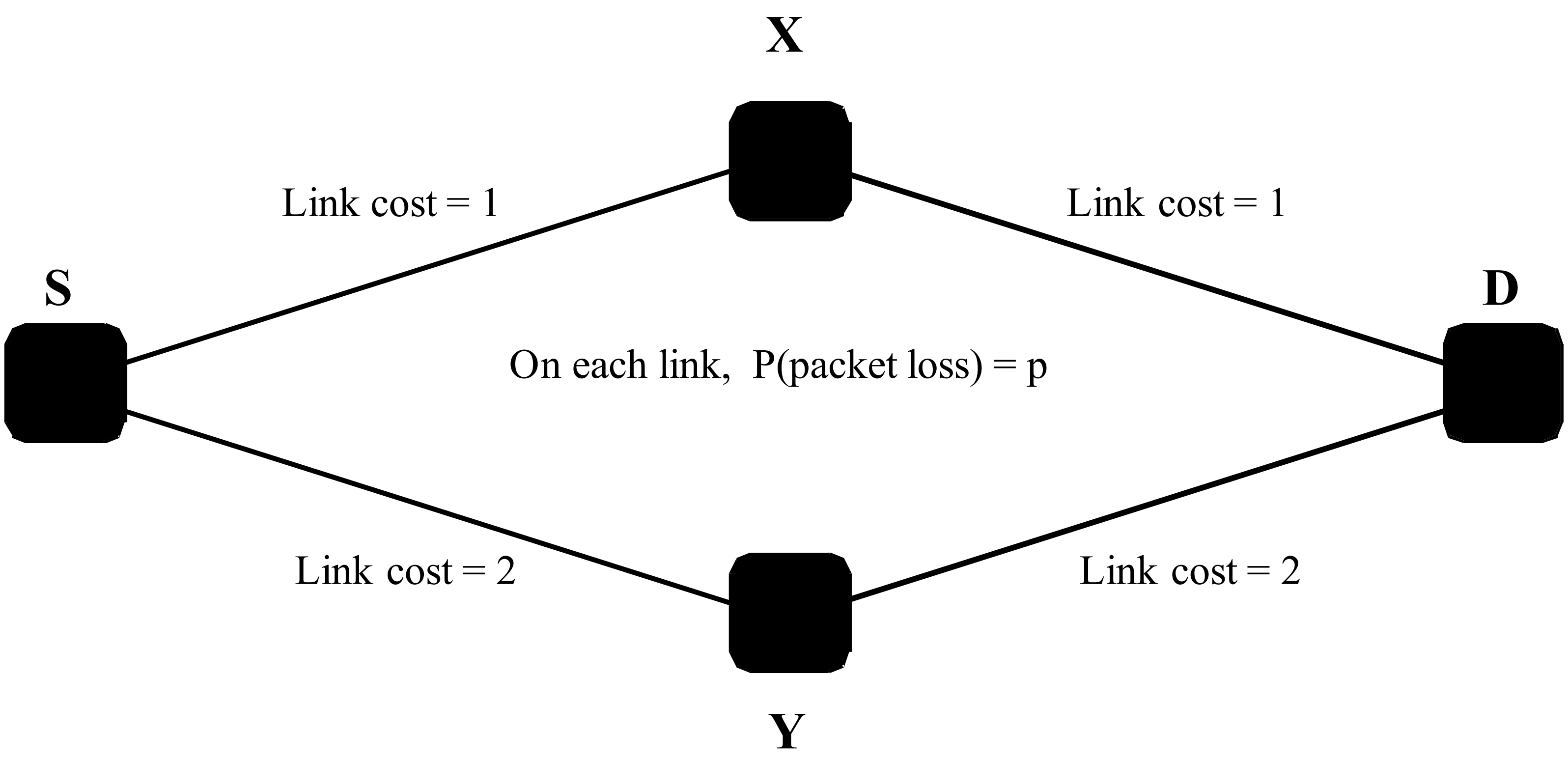
- Stochastic nature of communication systems
- Hence analytical modelling is
  - Typically complex
  - Heavily dependent on statistics
    - Good understanding of statistics pivotal(!)
  - Conducted by "mapping" system to one of several "classical" analytical models
    - i.e. not starting from scratch and proving all foundational mathematics & statistics but rather build upon existing proven results
- As expected, lots of flavours of analytical models exist
  - Some general guidelines exist
- Best to consider a simple case study

A Practical Guide to Analytical Modelling

1. **Clearly define your goals**
   - What is success?
2. **Select metrics & identify parameters**
   - What metrics should be used to evaluate the system?
   - What parameters affect the system? Which are varied in study?
3. **Conduct thorough literature survey**
   - What are the best 2/3 existing analytical models of similar systems?
4. **Select the analytical model you will use**
   - What is the most promising model, given your constraints?
5. **Conduct literature survey of chosen analytical model**
   - Do you understand key aspects of underlying maths & stats?
6. **Model your system**
7. **Solve resulting equations**
   - May require specialised mathematical software
8. **Analyse and interpret data**
9. **Present results**

Steps 3 - 8 may require assistance from a mathematician/statistician

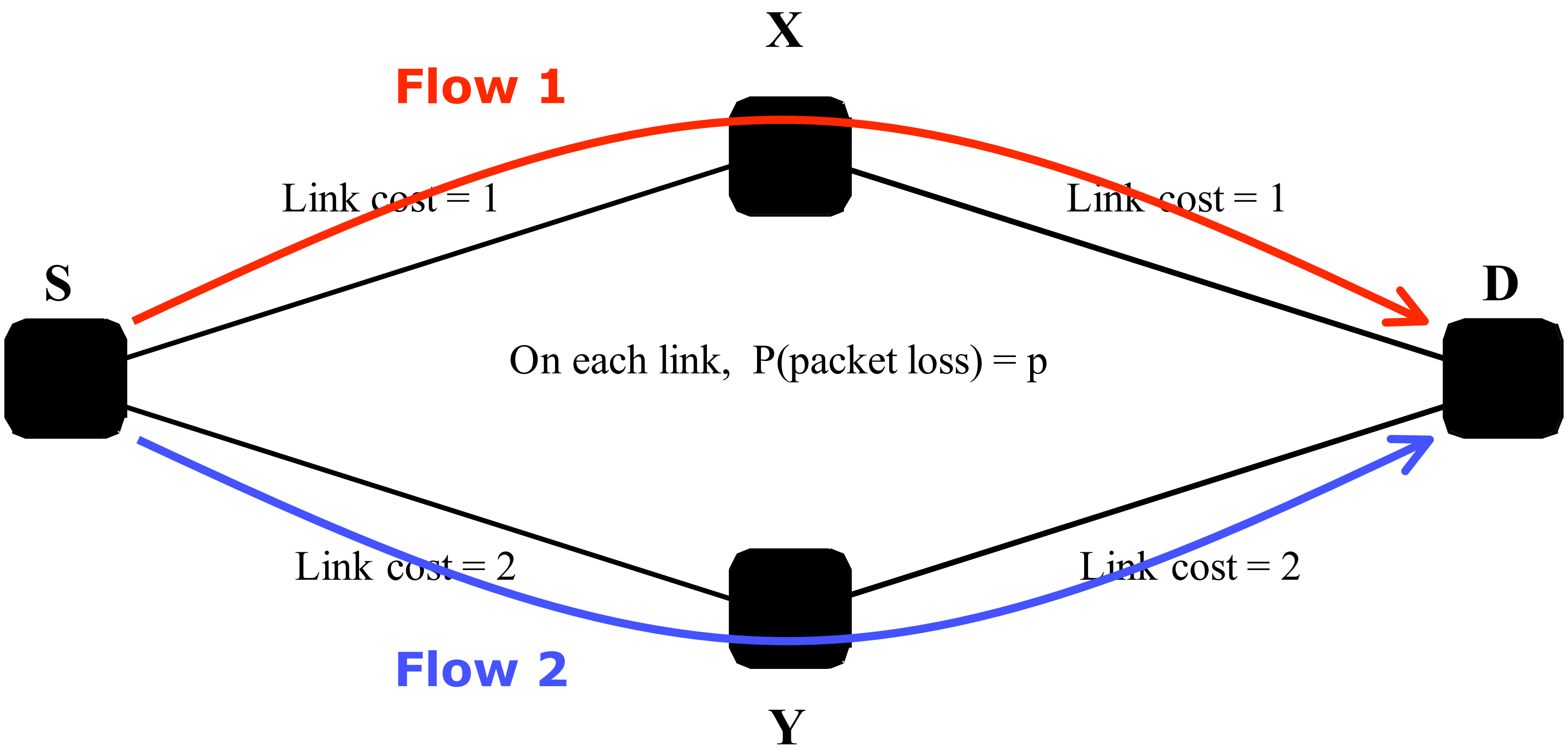
Analytical Modelling: Case Study



S wishes to set up two consecutive connections D

Only one flow can accommodated per link…

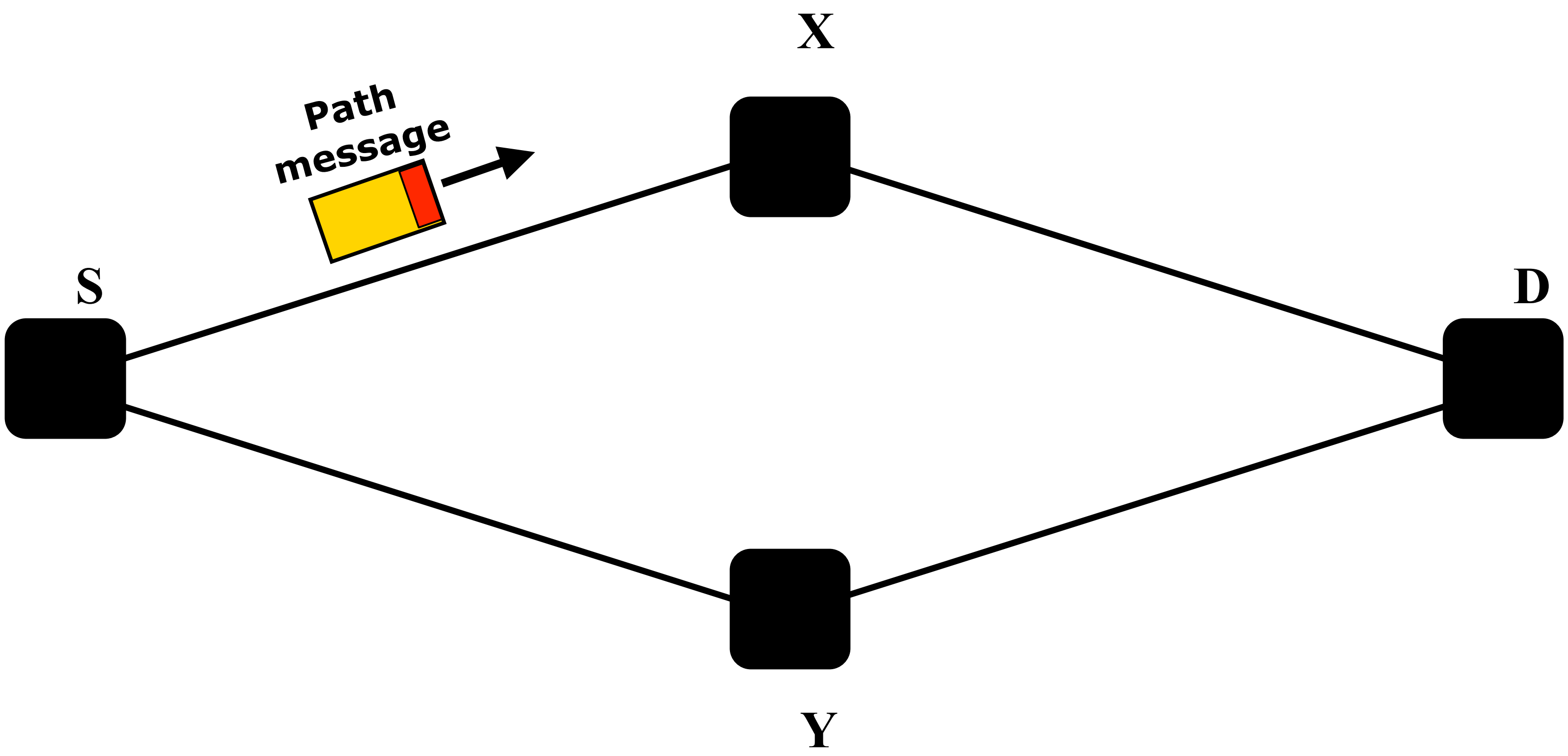
Analytical Modelling: Case Study



Ideal scenario

Dependent upon receipt of appropriate signalling and routing messages BUT packets may be lost!!

Analytical Modelling: Case Study



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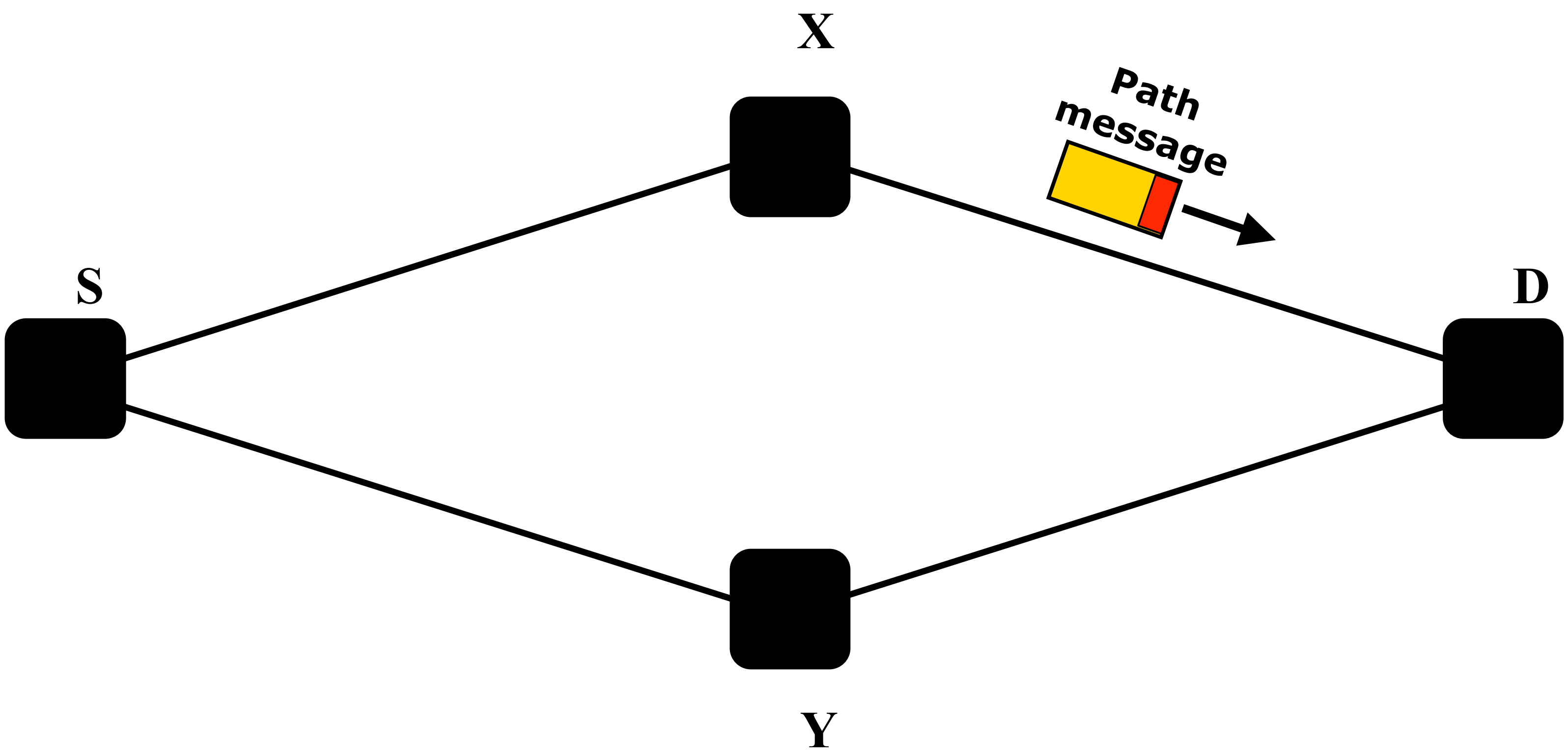

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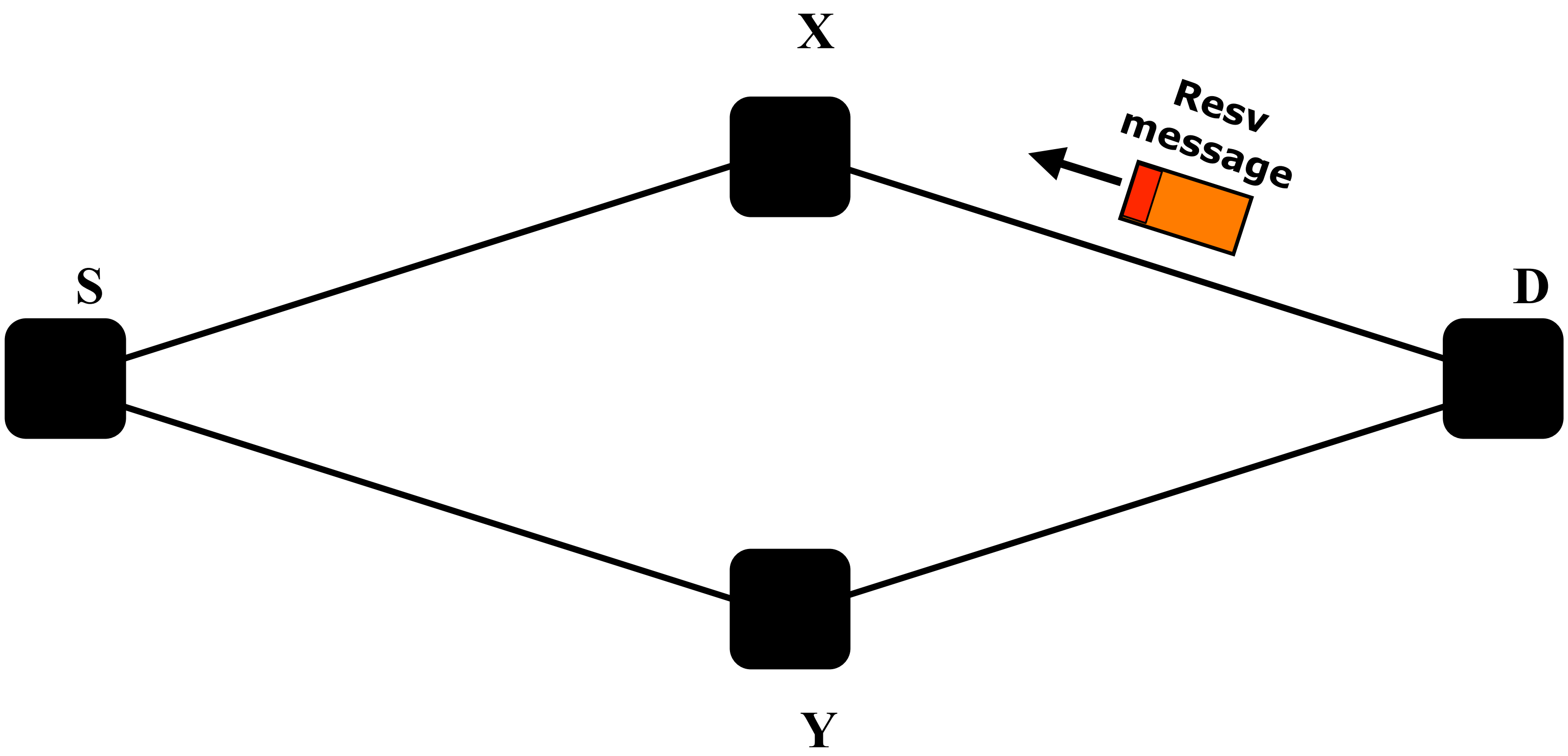

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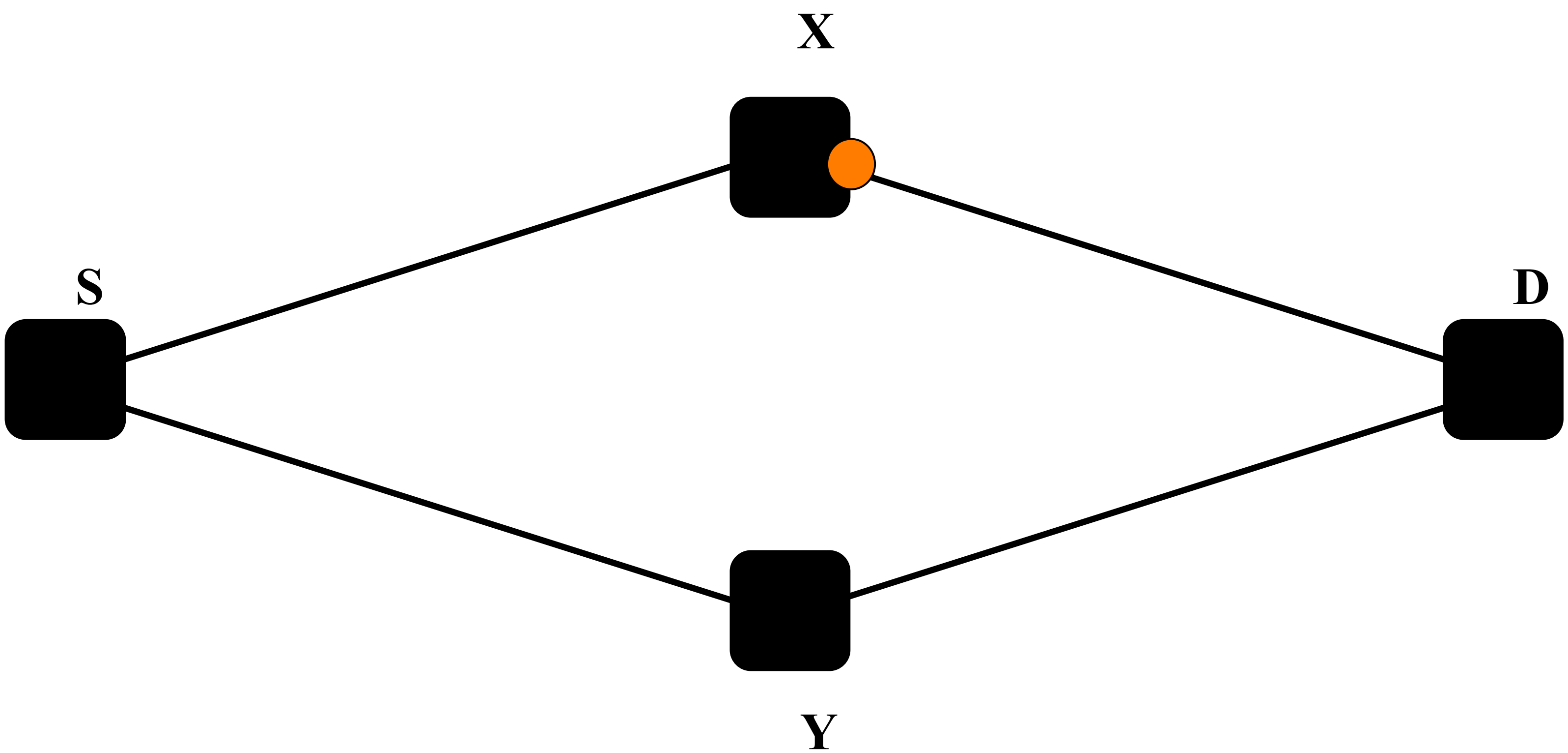

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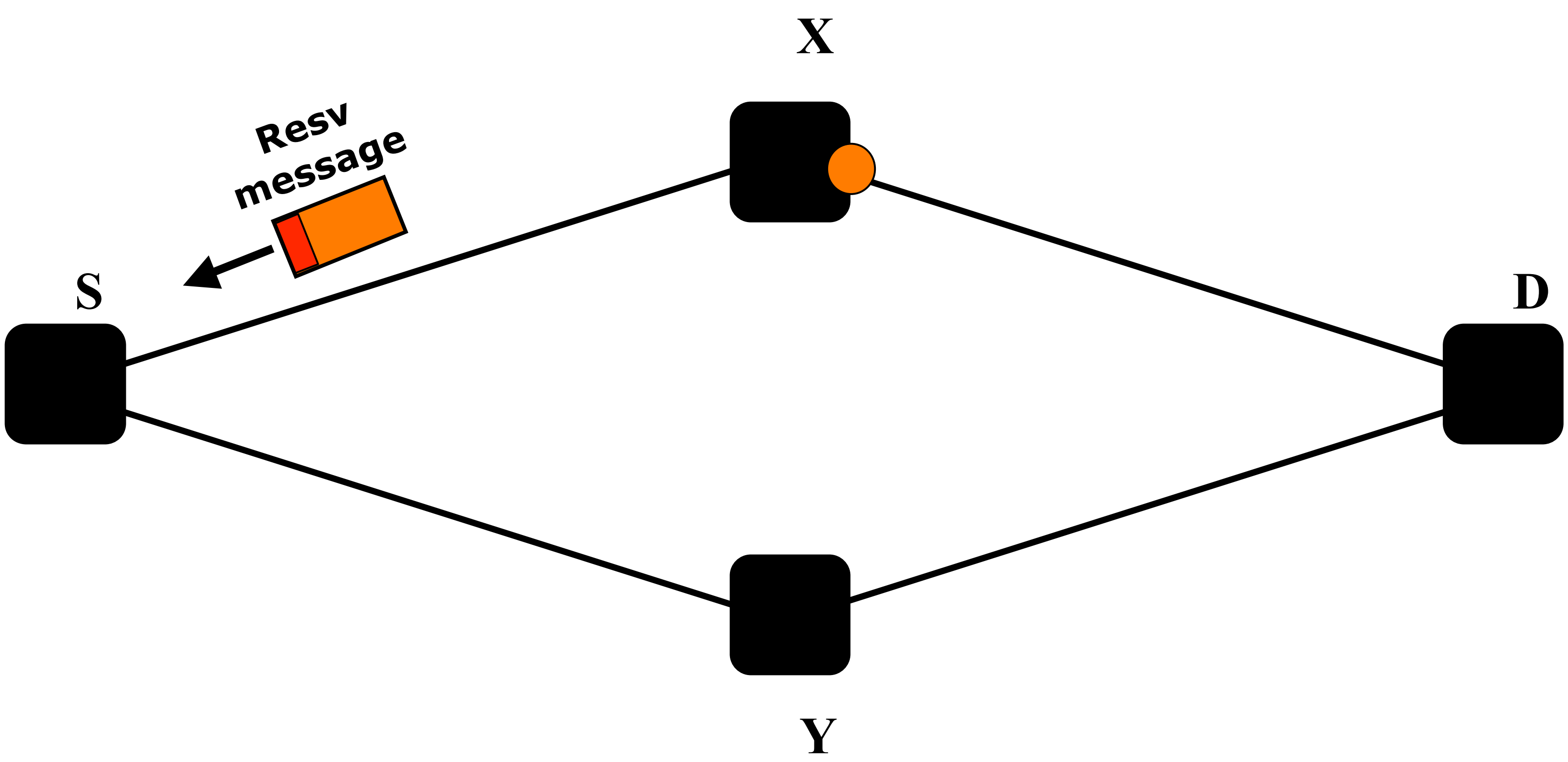

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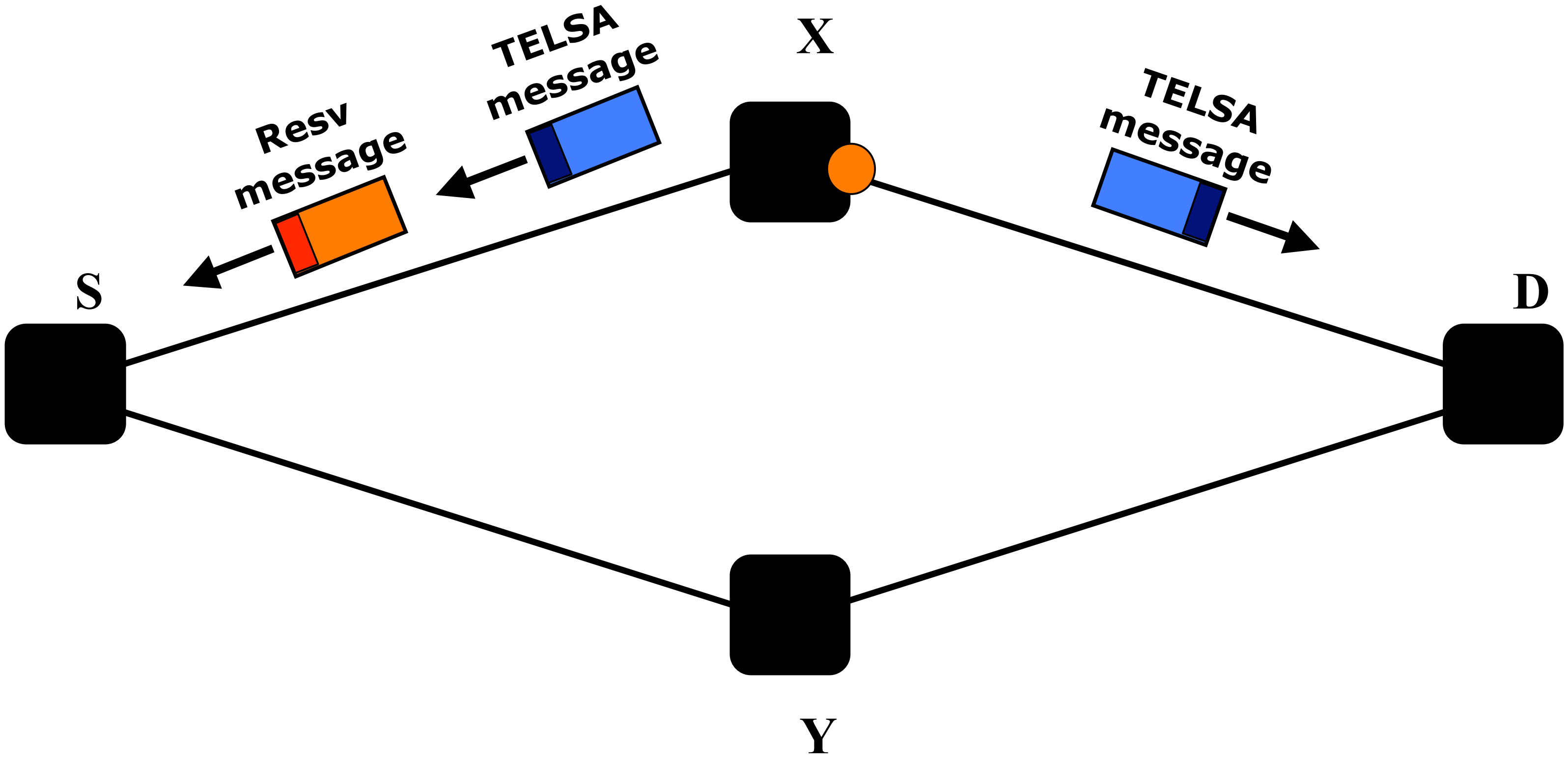

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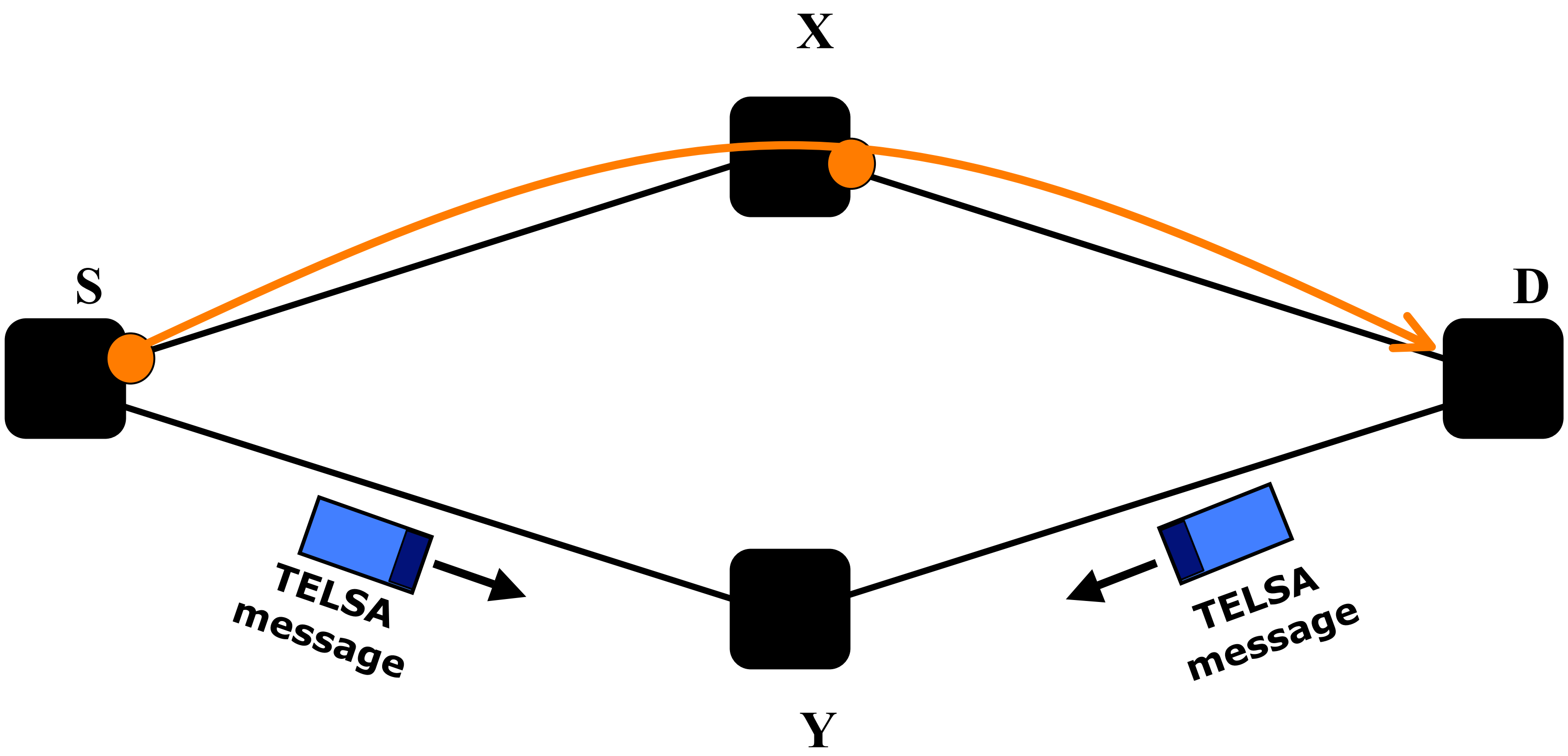

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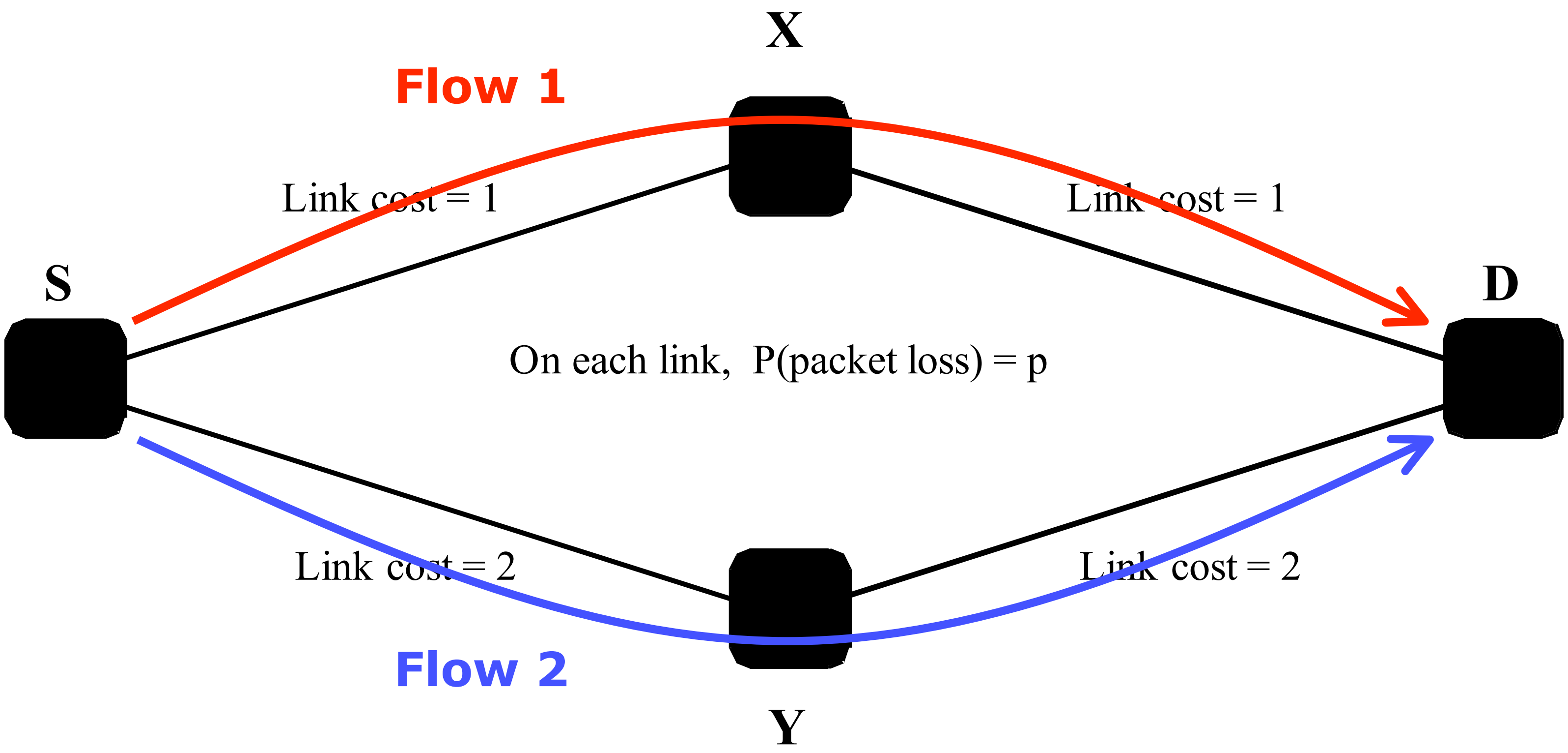
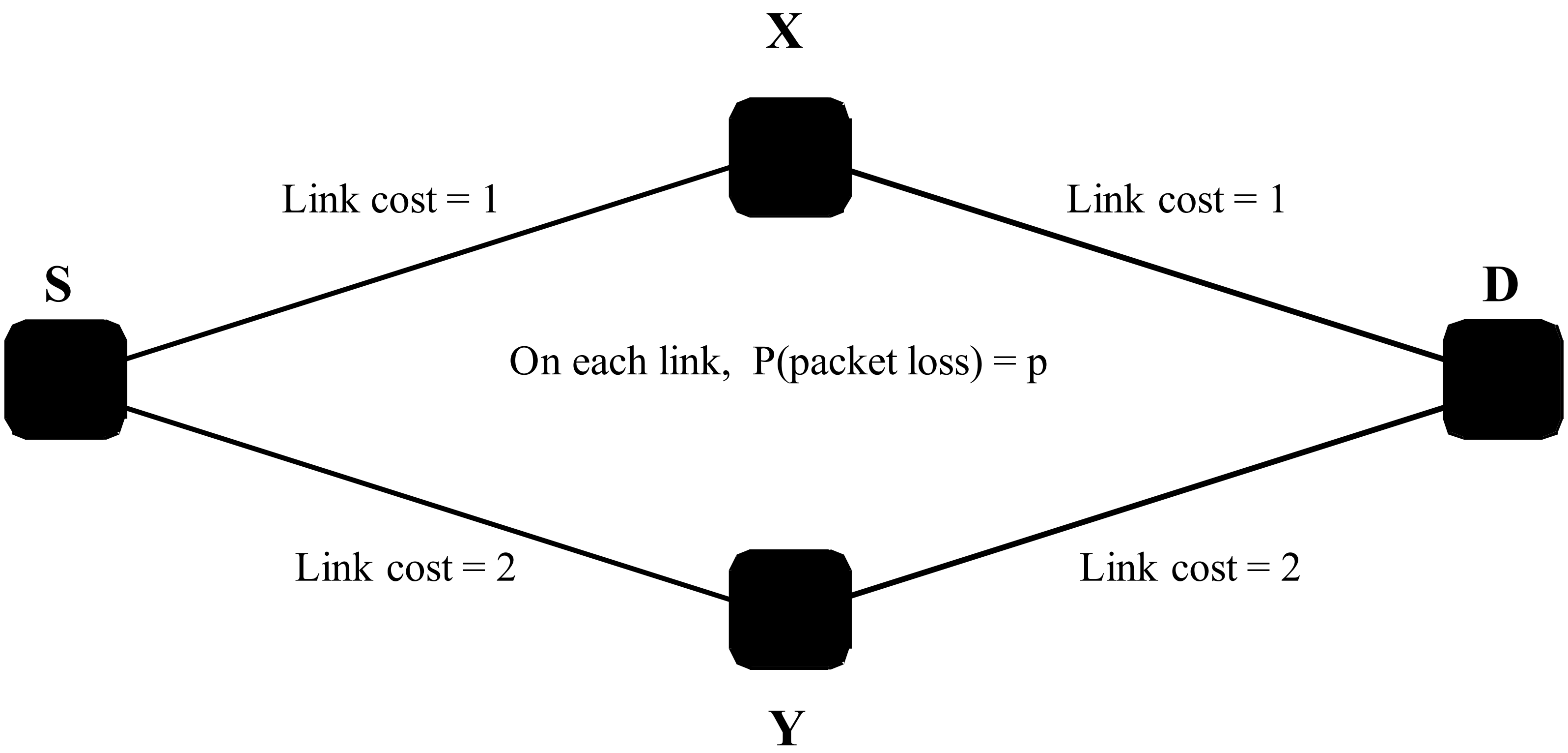


Ideal scenario

Dependent upon receipt of appropriate signalling and routing messages BUT packets may be lost!!

Using Modelling to Evaluate Performance



Given a packet loss probability of *p*

What is the probability of both flows being correctly established?

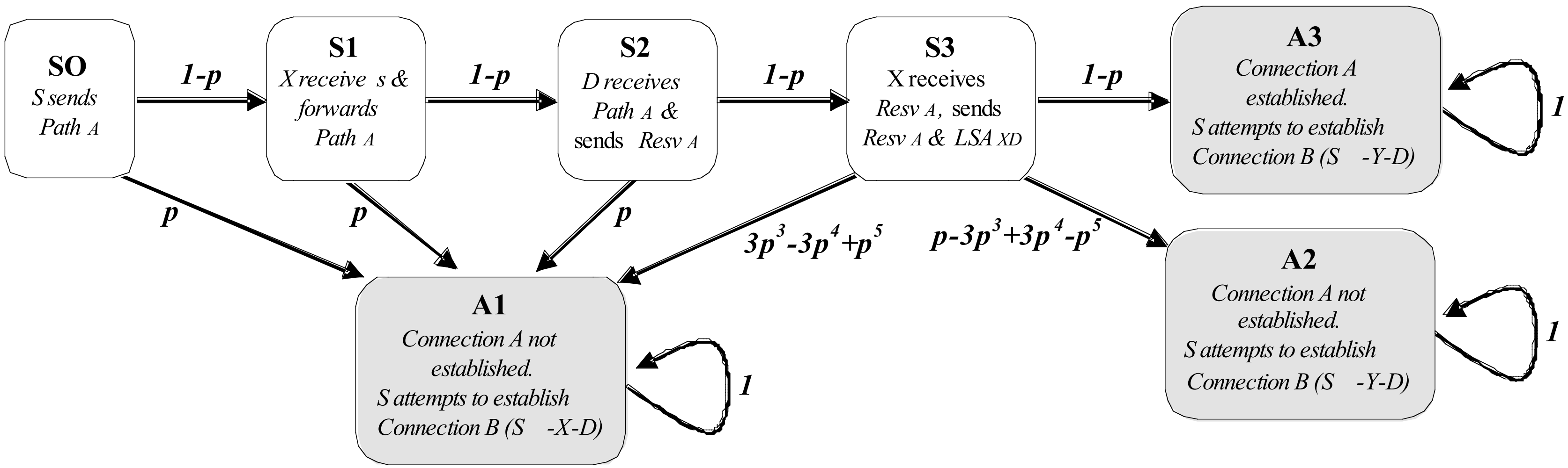
What is the probability of only one flow being correctly established?

Analytical Modelling: Case Study

1. **Clearly define your goals**
   - *Study impact of routing and signalling message loss*
2. **Select metrics & identify parameters**
   - *Metric: Probability of flows being correctly established*
   - *Parameters: Probability of routing and signalling message loss*
3. **Conduct thorough literature survey**
   - *Identified 2/3 possible analytical models*
4. **Select the analytical model you will use**
   - *Absorbing Markov Chains*
5. **Conduct literature survey of chosen analytical model**
   - *Understood key aspects of underlying maths & stats*
6. **Model your system**
7. **Solve resulting equations**
   - May require specialised mathematical software
8. **Analyse and interpret data**
9. **Present results**

Steps 3 - 8 may require assistance from a mathematician/statistician

State Transition Diagram: No Retransmission



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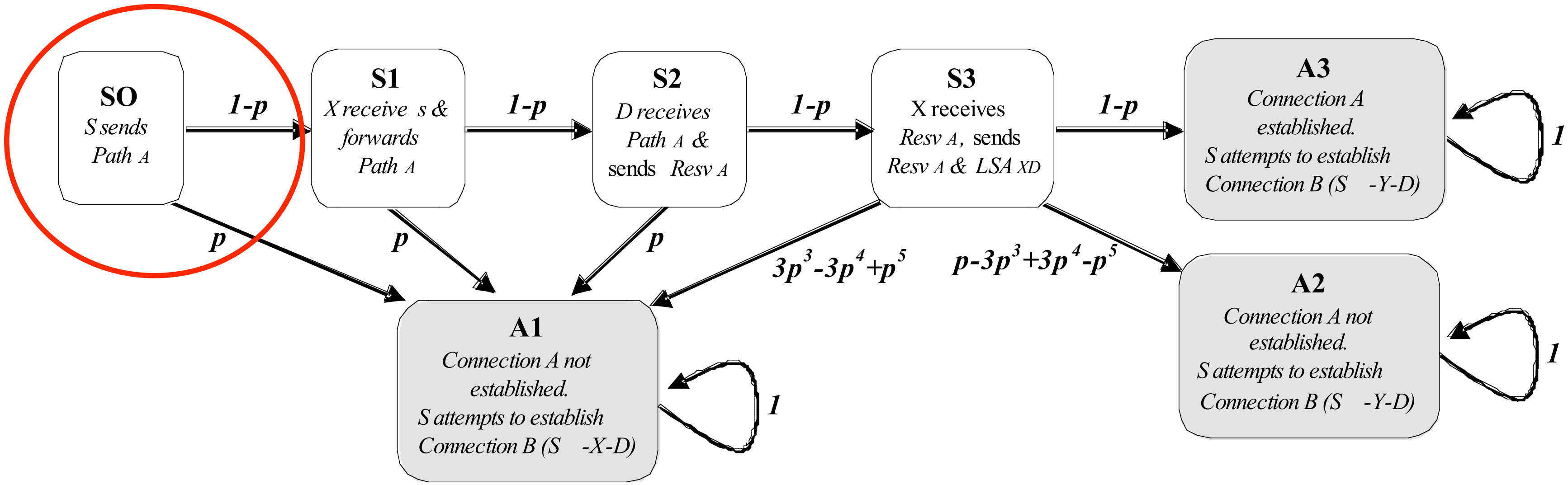

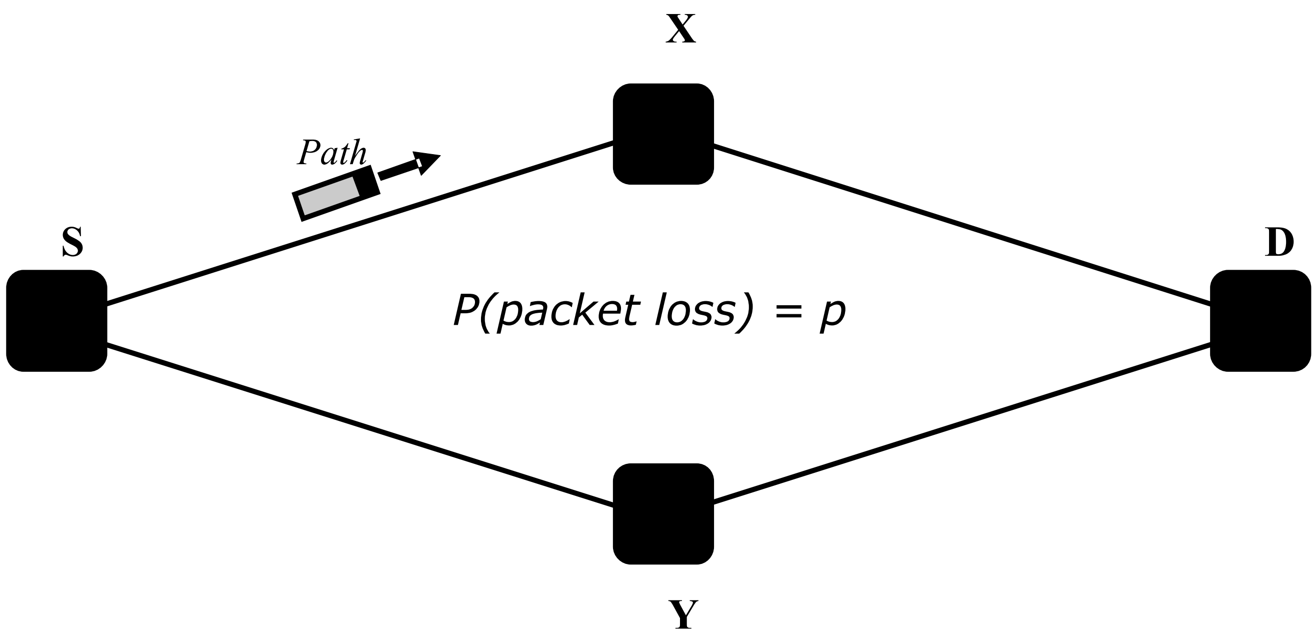

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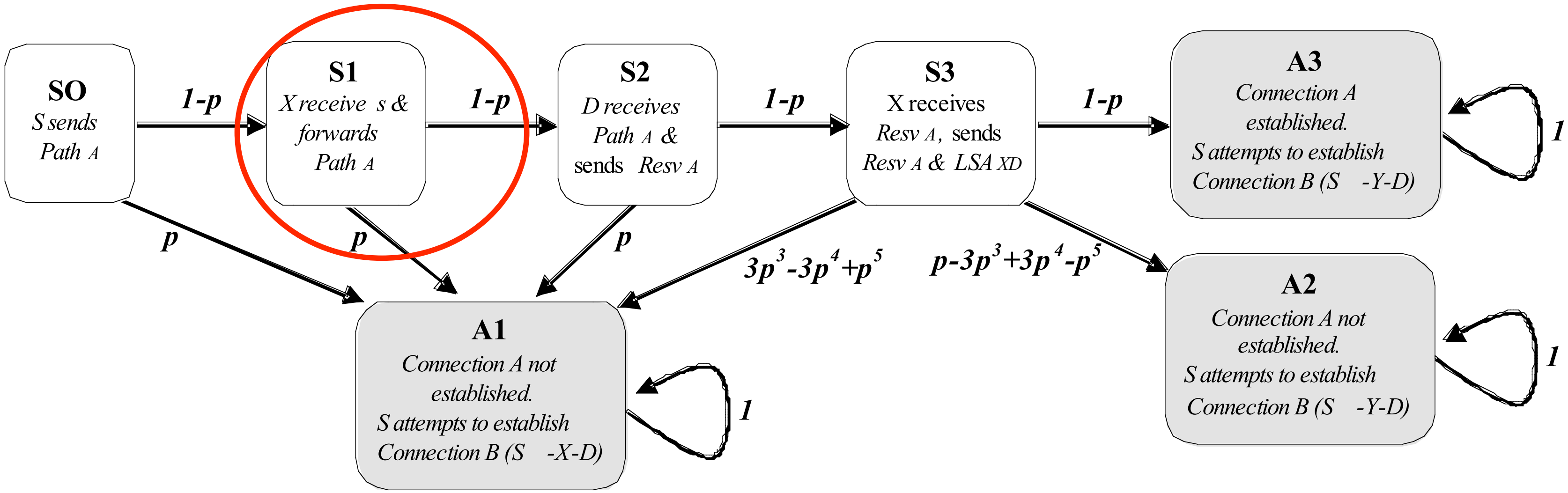

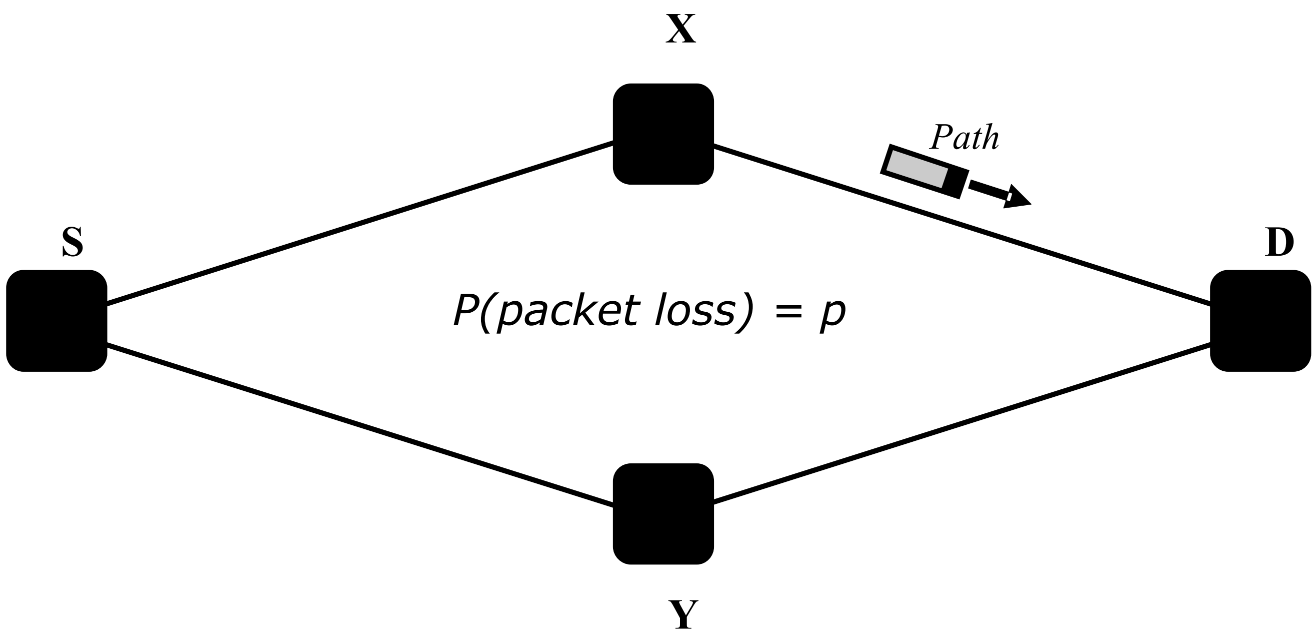

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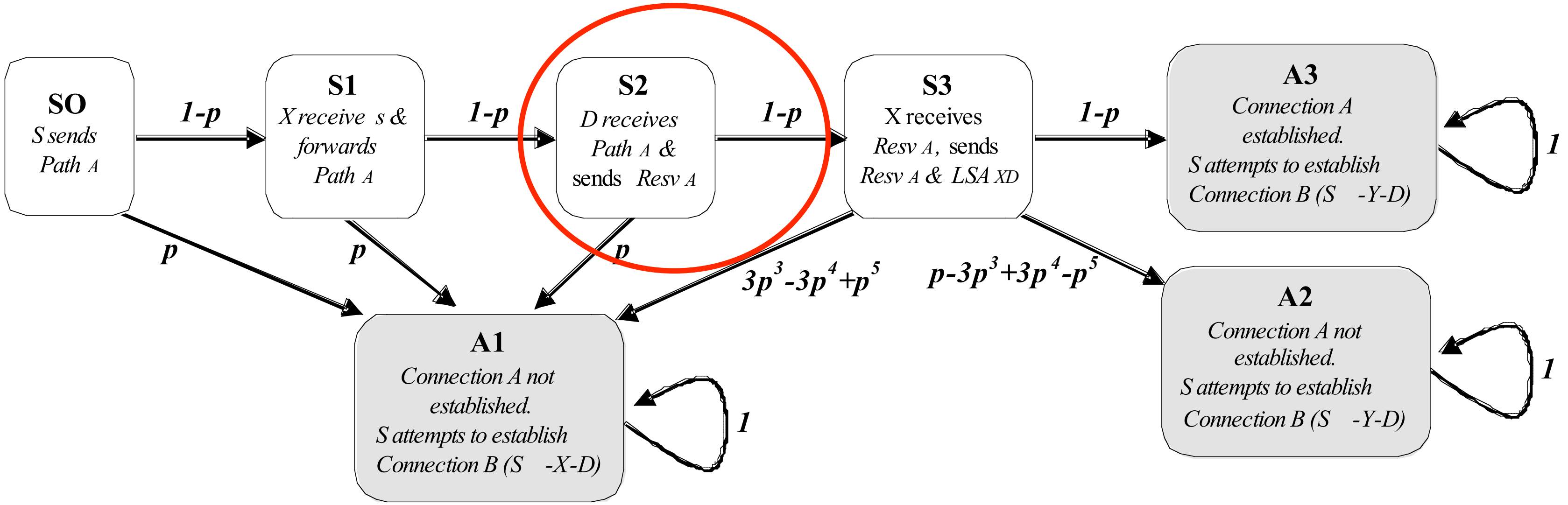

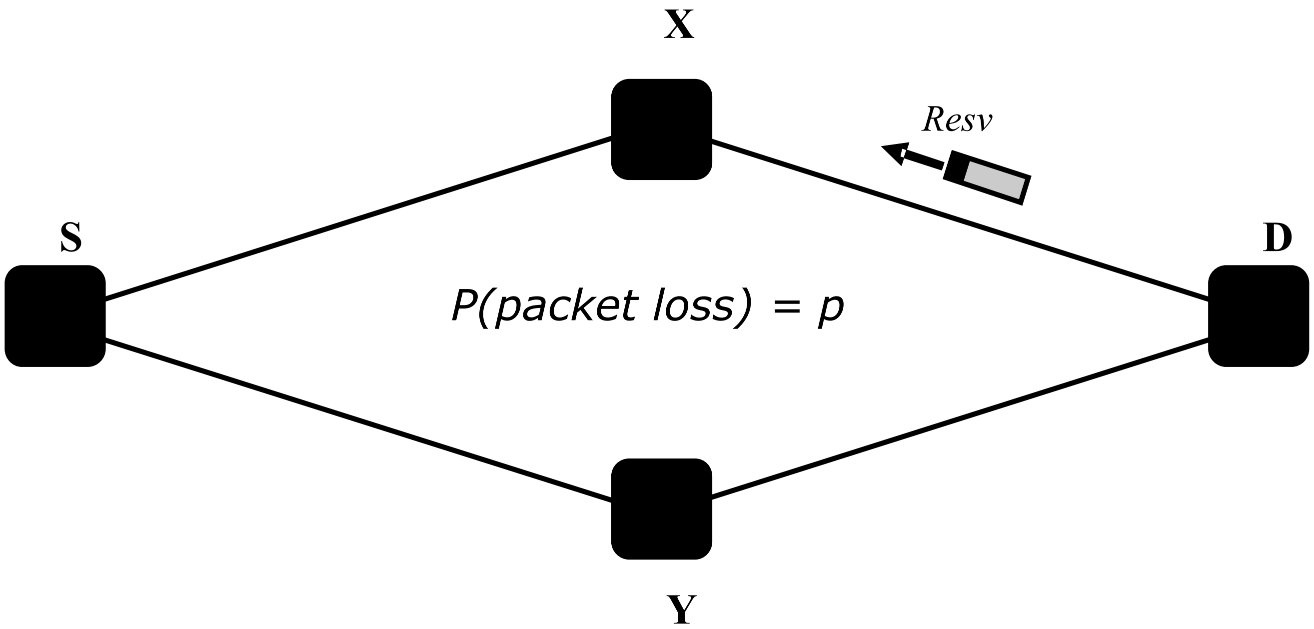

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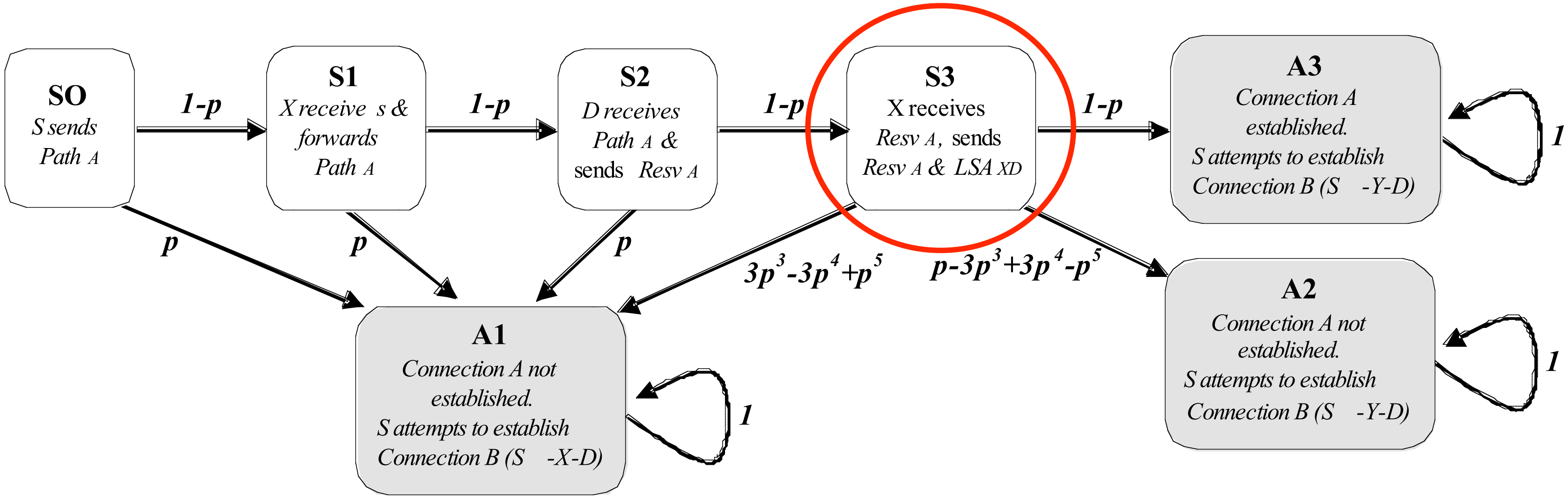

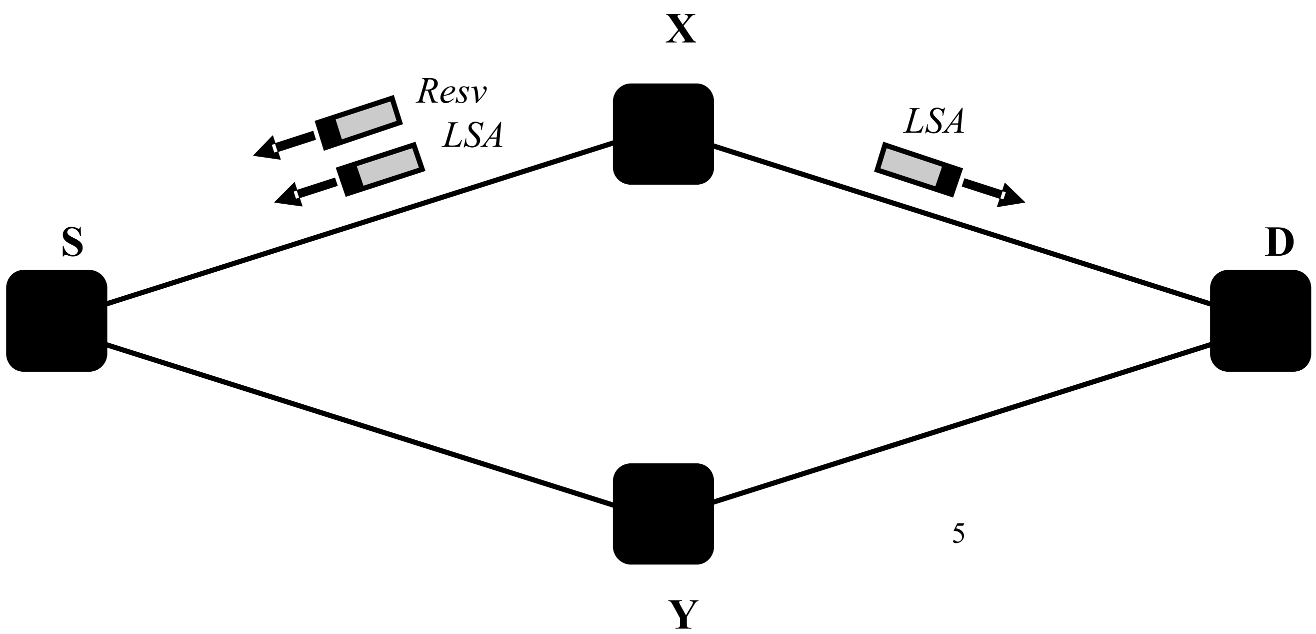

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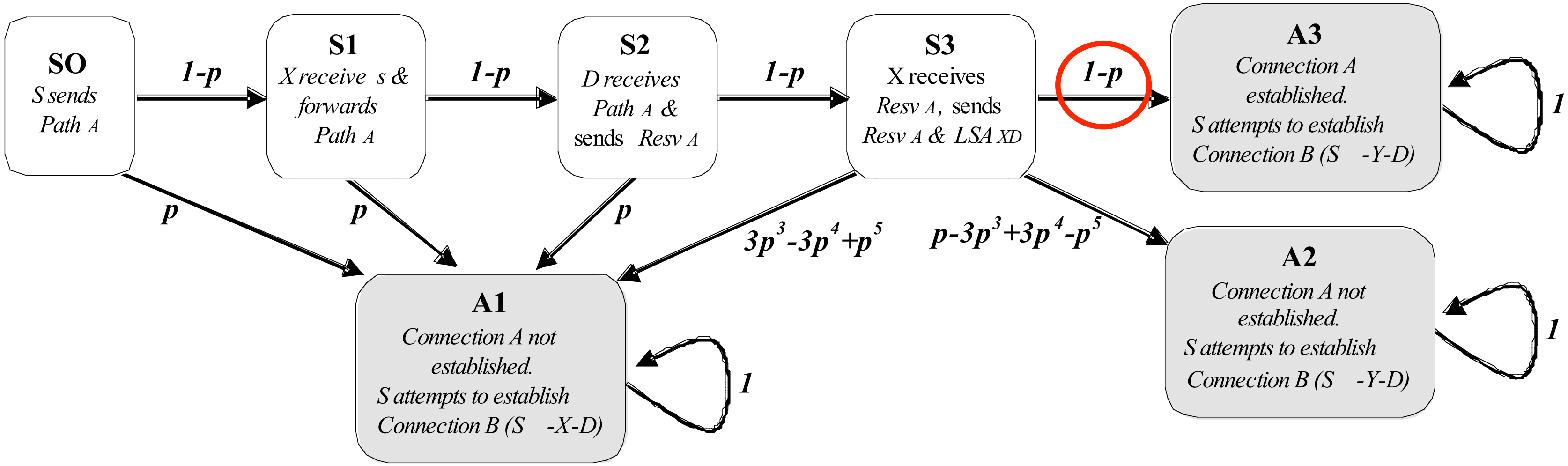

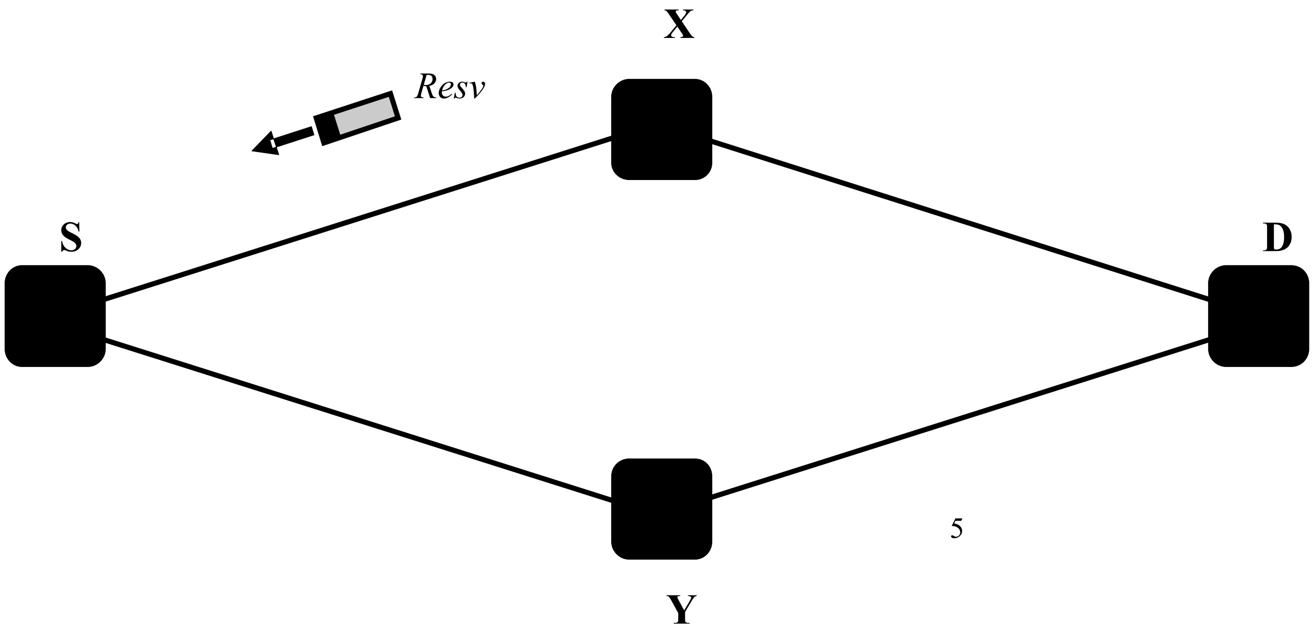

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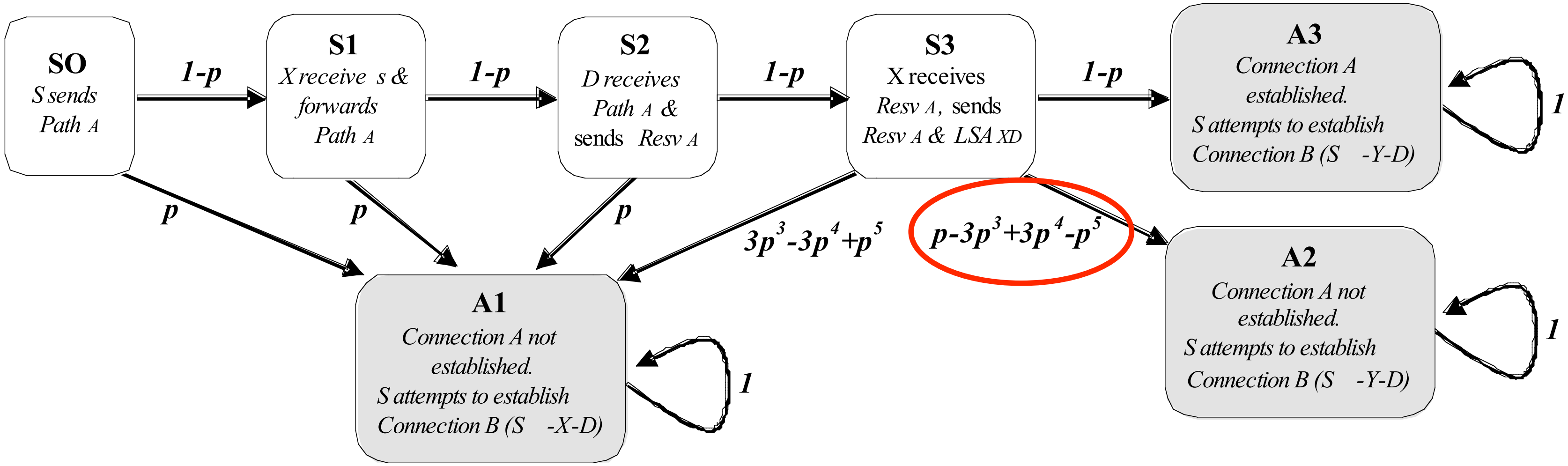
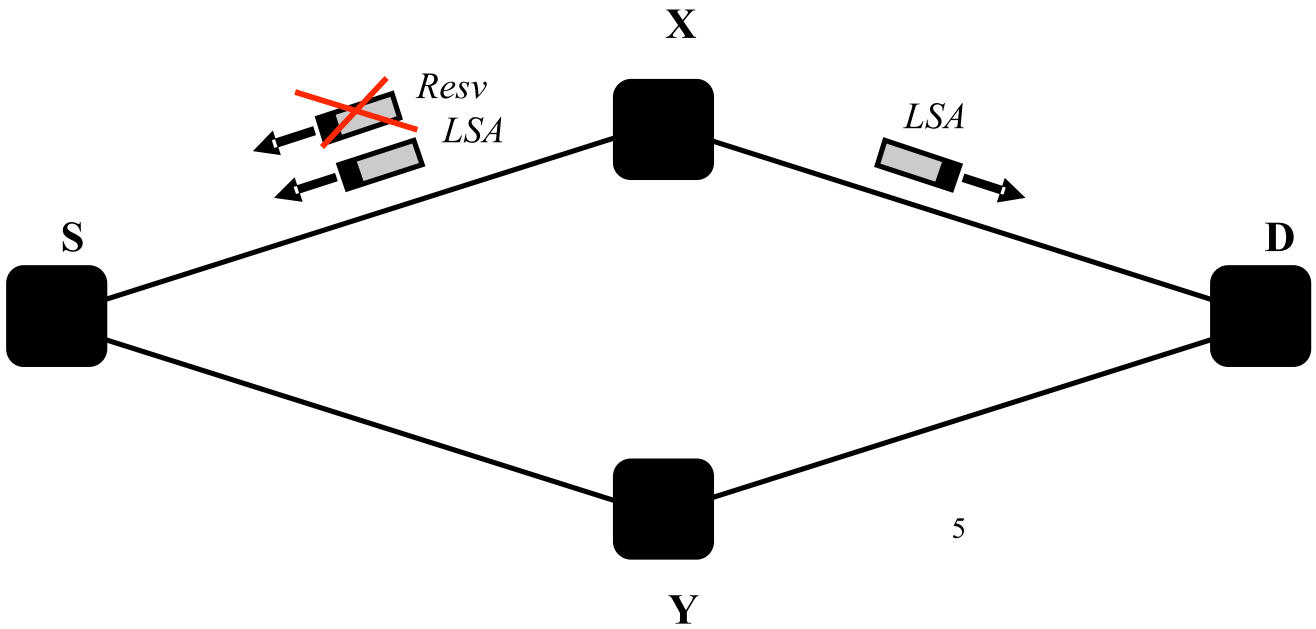
State Transition Diagram: No Retransmission





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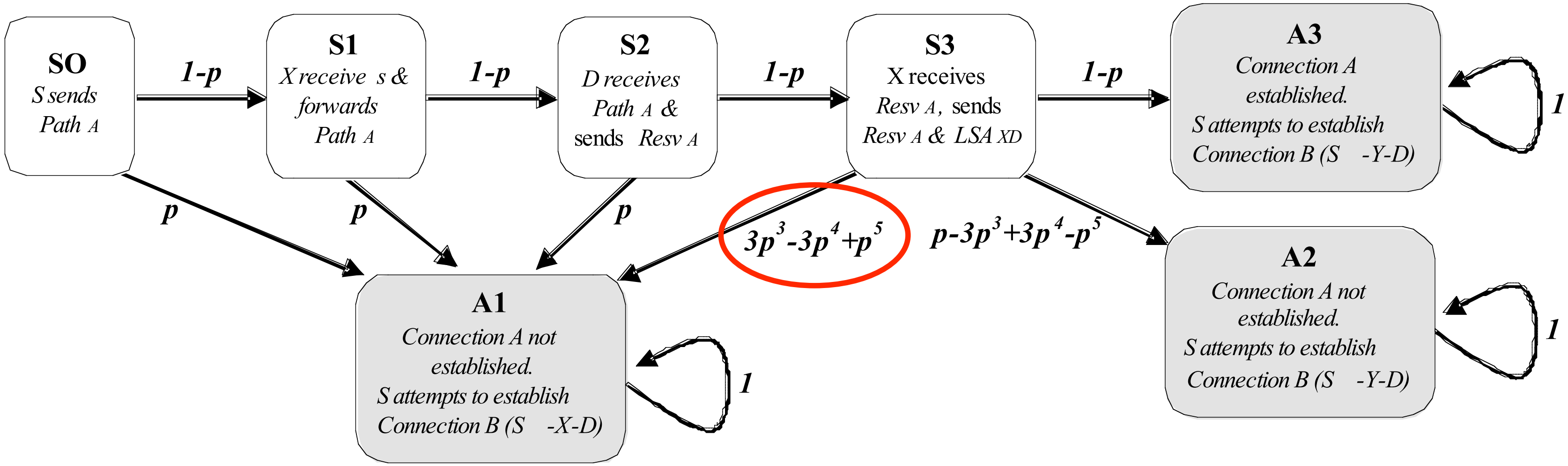
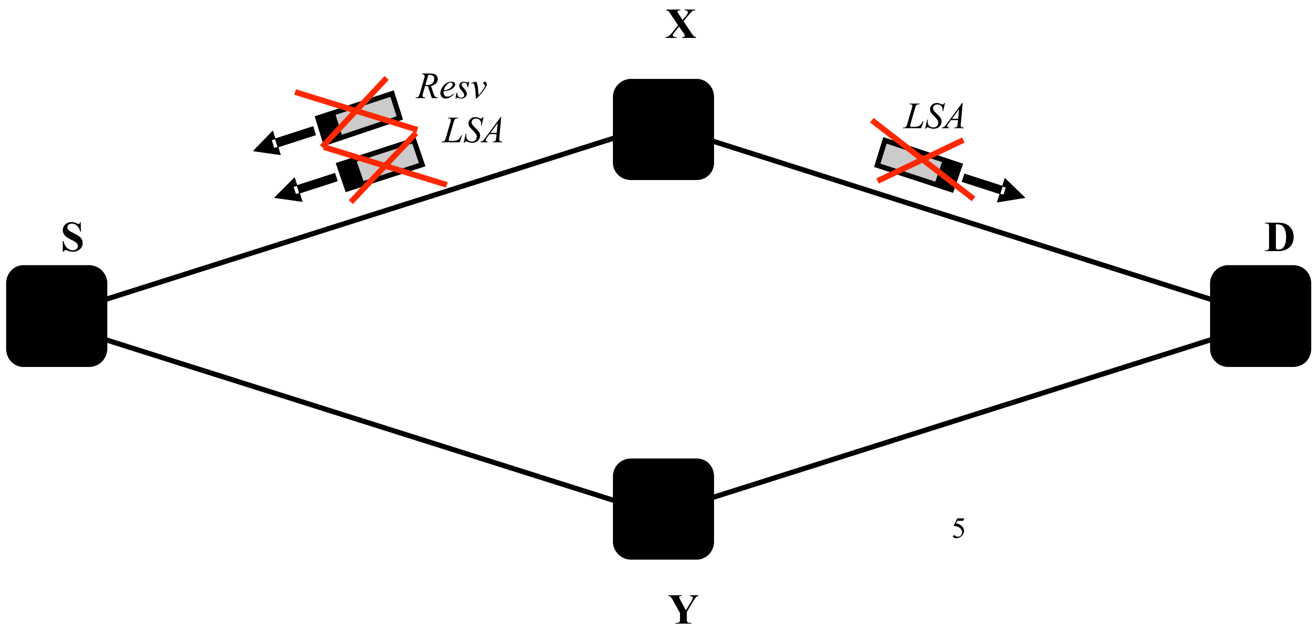
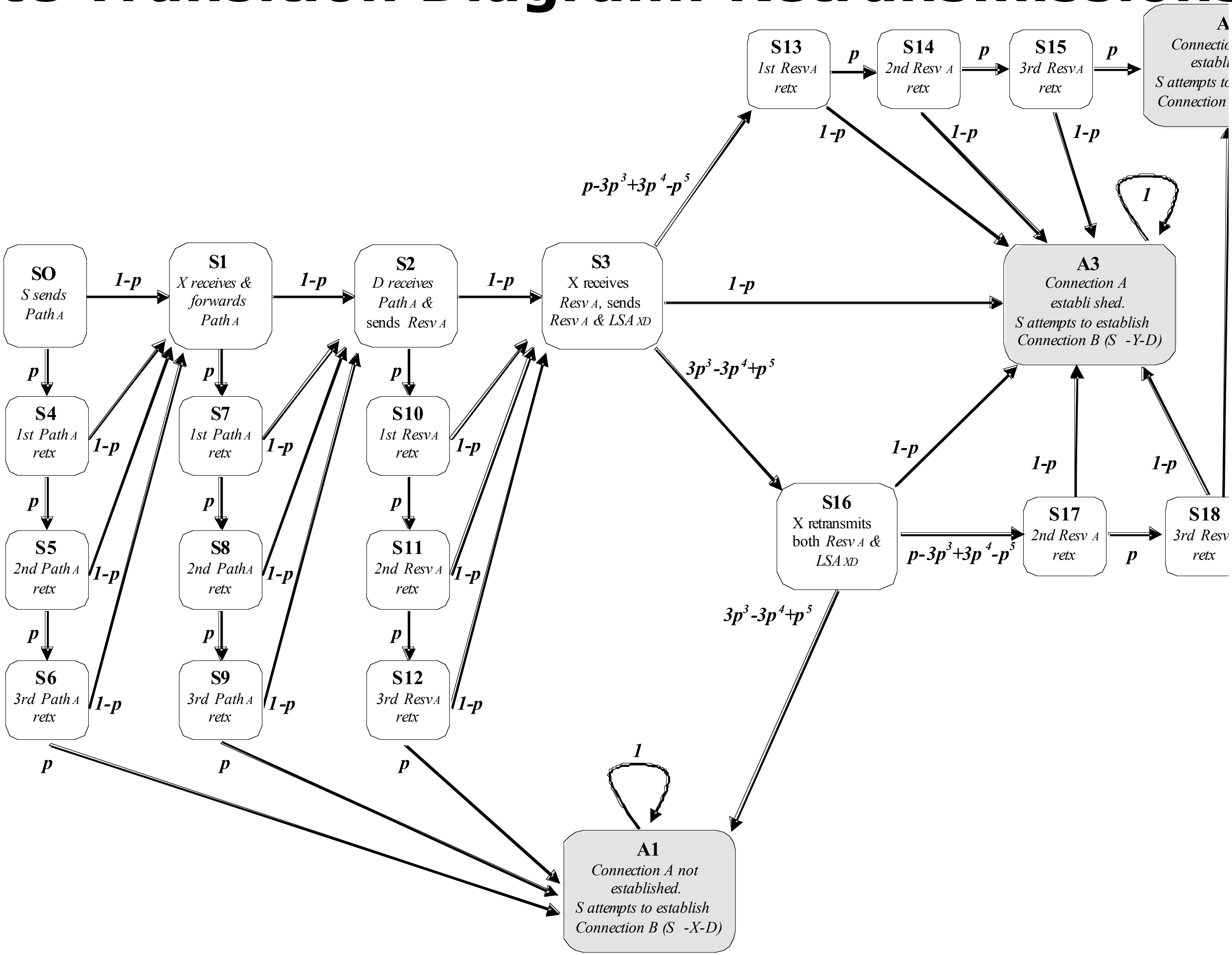




Evaluating System Performance

- State transitions describe system behaviour
- Must "solve" to evaluate system performance
- Based on theory of absorbing Markov chains
  - Markov Chain
    - Special type of discrete state stochastic process
    - Probability distribution at time *t+1* depends only at state at *t* (and not state at *t-1, t-2,t-3, … 0*)
  - Absorbing State
    - A state from which there is zero probability of exiting
- Use known results of absorbing Markov chains to compute probability of absorption in particular absorbing state as function of p….
  - Write out state transition matrix (Table 1)
  - Isolate transitions between non-absorbing states (Q, Table II)
  - Isolate transitions between absorbing states (R, Table III)
  - Compute fundamental matrix, $F = (I-Q)^{-1}$
  - Compute absorption probabilities by calculating X = FR
    - Probabilities given in Equations 1 - 3

State Transition Diagram: Retransmissions



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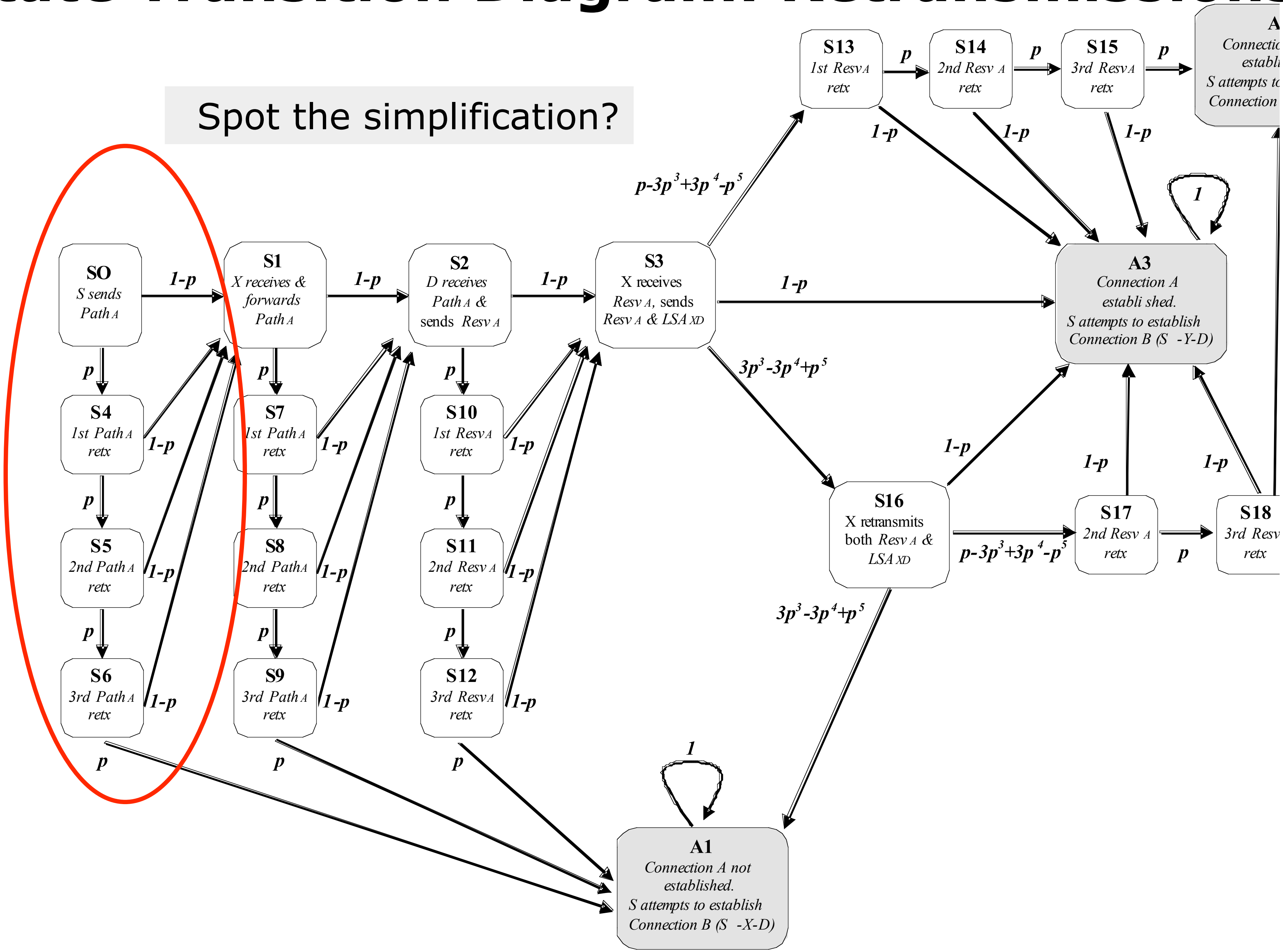

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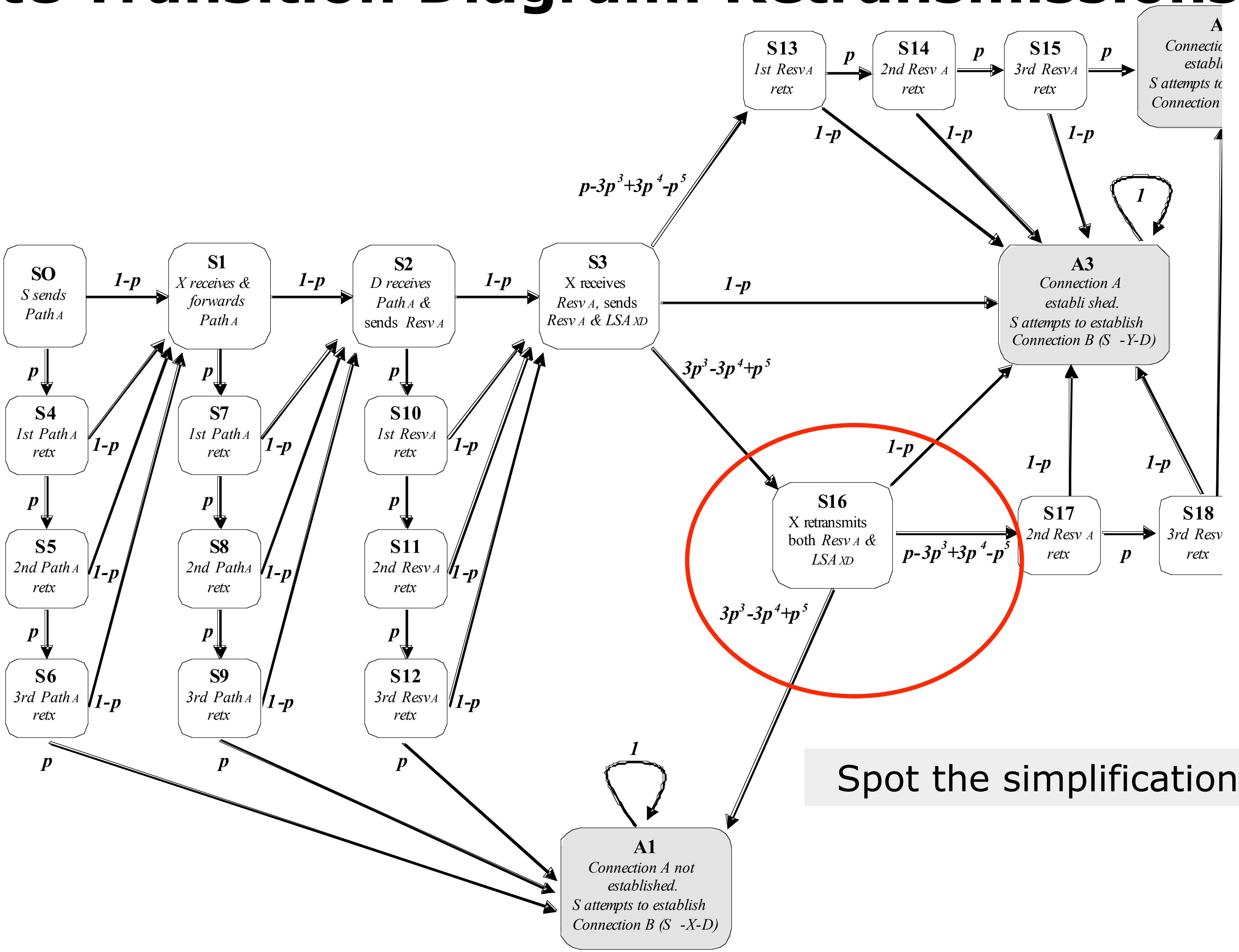
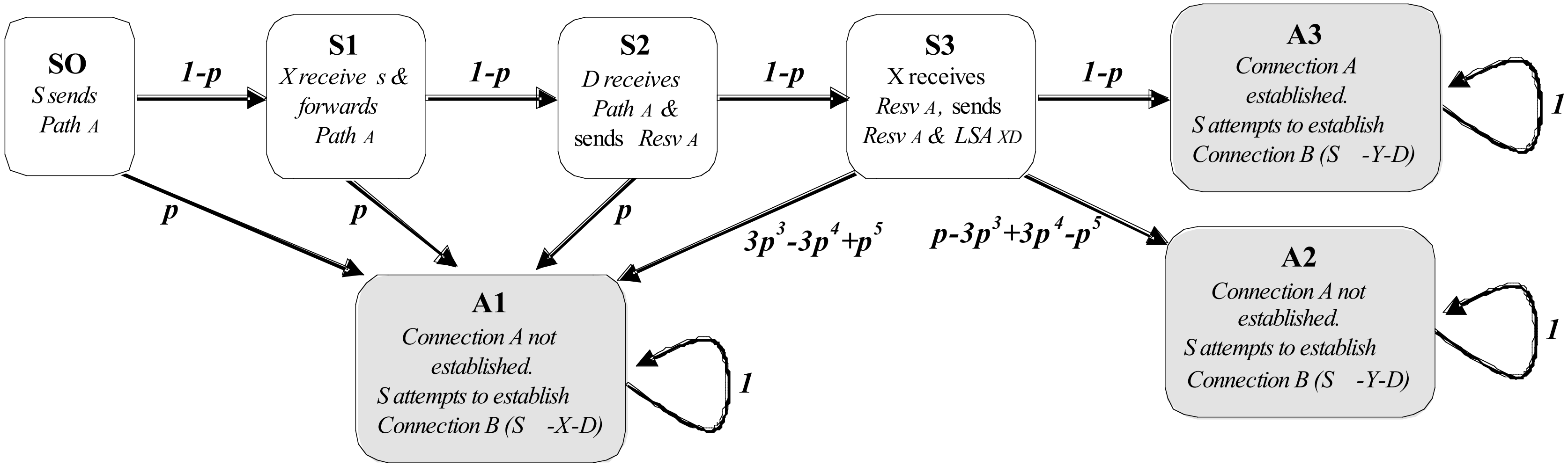


Spot the simplification?

Simulation Modelling vs Analytical Modelling

Analytical Modelling

System performance evaluated by ***describing and analysing*** state space statistically

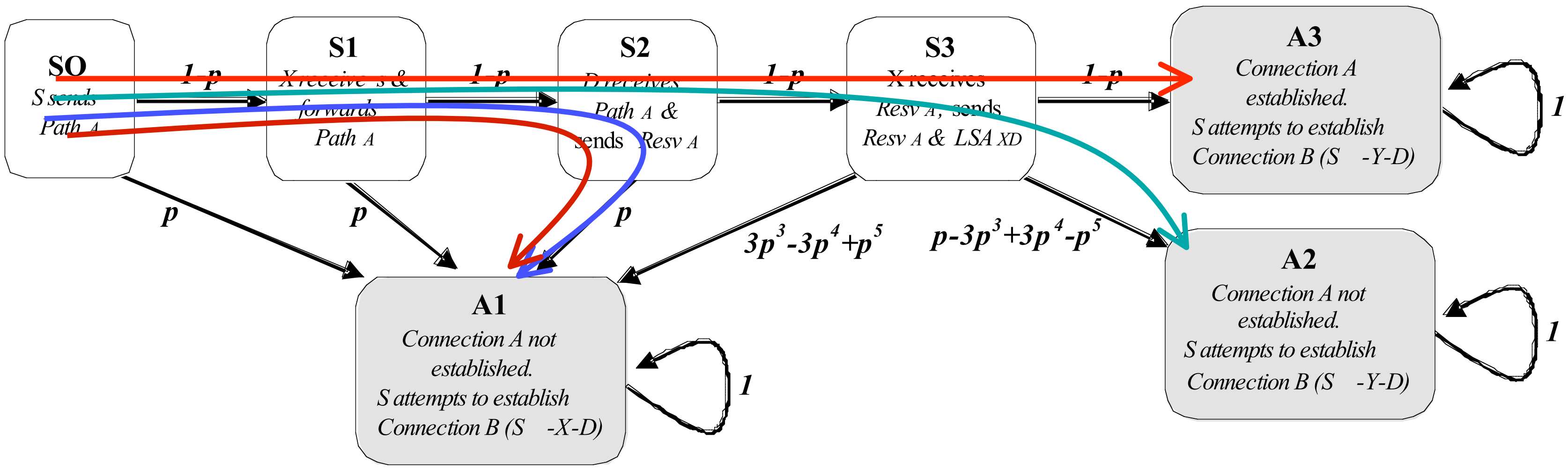


Solving equations gives insight into system performance

Simulation Modelling vs Analytical Modelling

Simulation Modelling

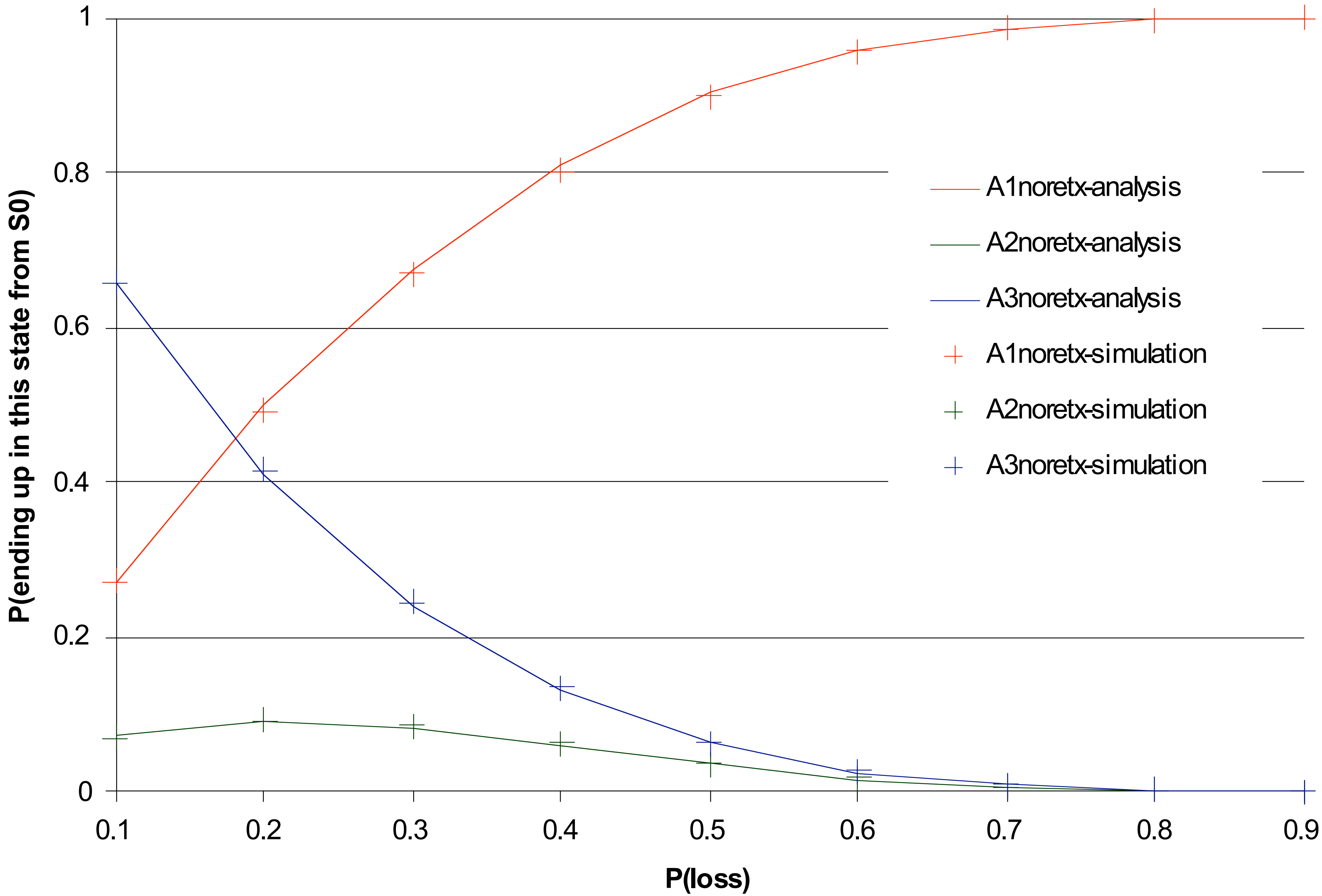
System performance evaluated by ***sampling*** state space



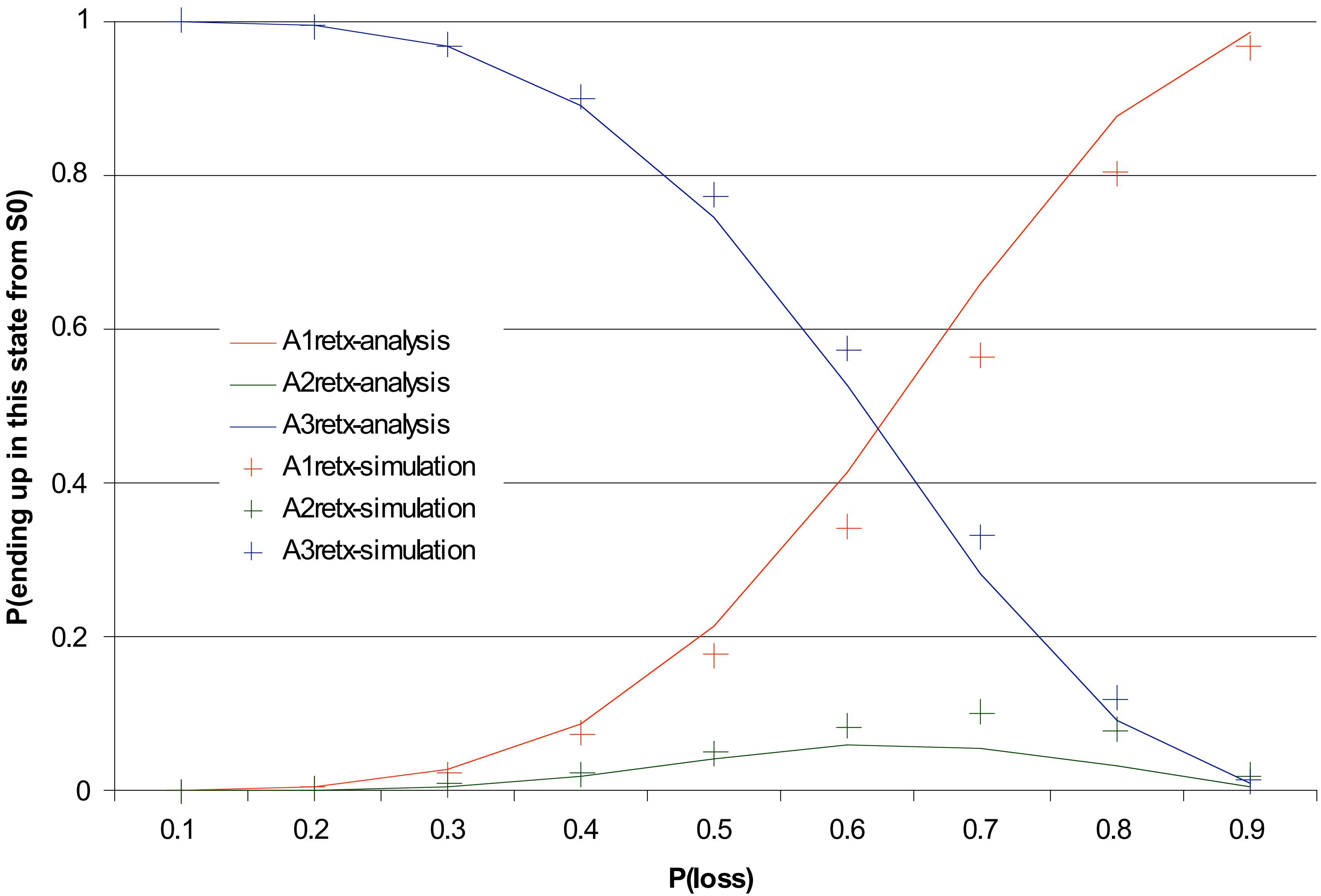
Each simulation run = sample of state space, hence critical to

- Take good & accurate samples (long simulation runs)
- Lots of samples (lots of simulation runs)
- Representative samples (good PRNG)

Simulation Modelling vs Analytical Modelling



Simulation Modelling vs Analytical Modelling



Analytical Modelling of the Grid

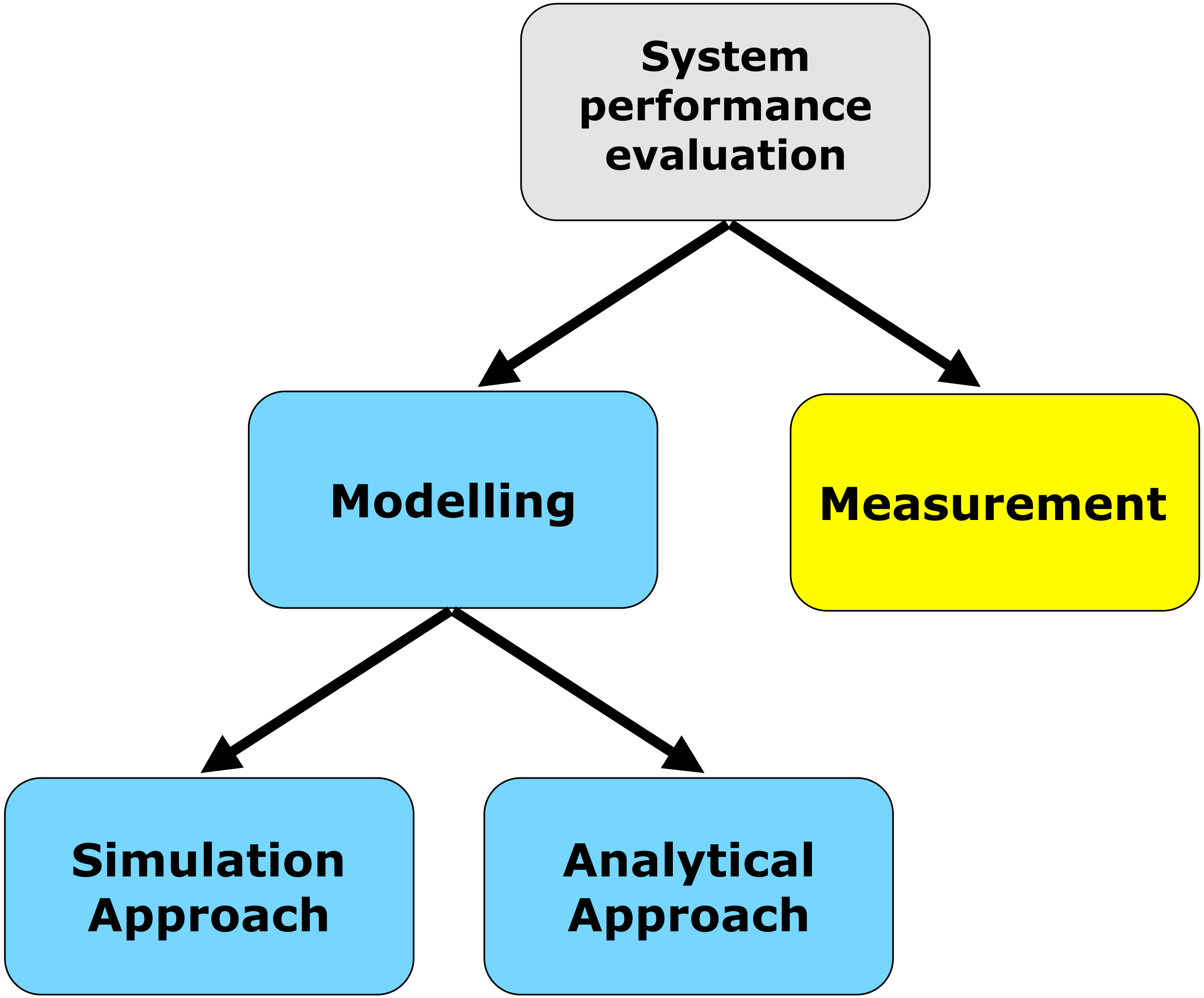
- Analytical models should be tractable
  - Small networks, simple scenarios, few packets, simplifications
- Hence, using analytical modelling for aspects of the Grid is far from trivial…. but worth the effort!

2 sentence summary

Challenging to conduct excellent analytical modelling of "traditional" networking systems

Even ***more*** challenging to conduct excellent analytical modelling of the Grid

Overview


System performance evaluation
Modelling
Measurement
Simulation Approach
Analytical Approach