QUANTIFYING HIDDEN VARIABLES USING BAYESIAN INFERENCE

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Introduction

- Performance Analyst at IMC
- Technology-driven trading
  - Amsterdam, Chicago and Sydney
- Networks and automation

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Problem: estimating hidden variables

Features

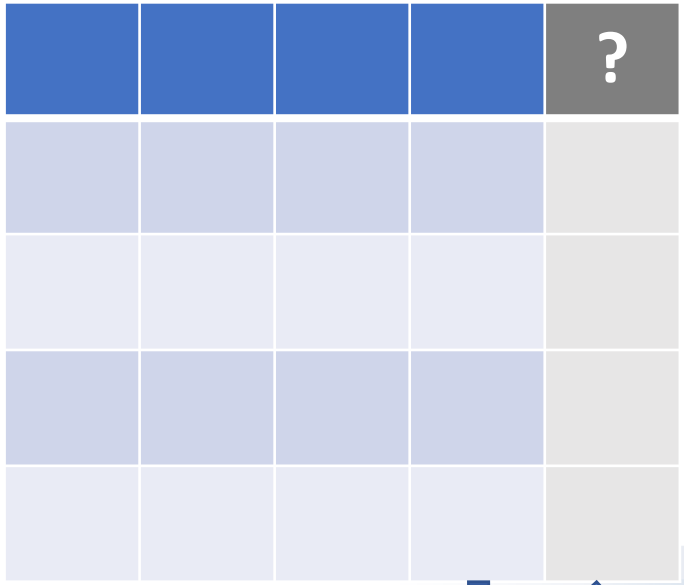
Observations

				?

Problem: estimating hidden variables

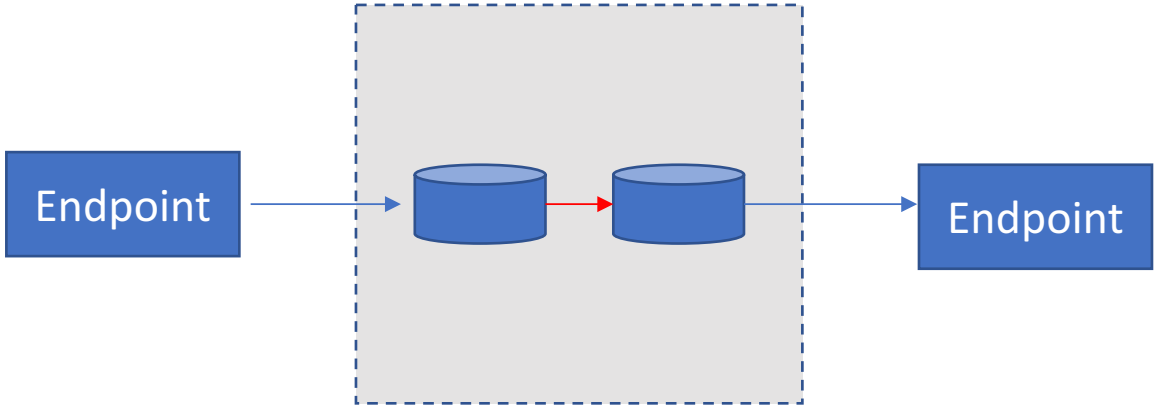
Features

Observations



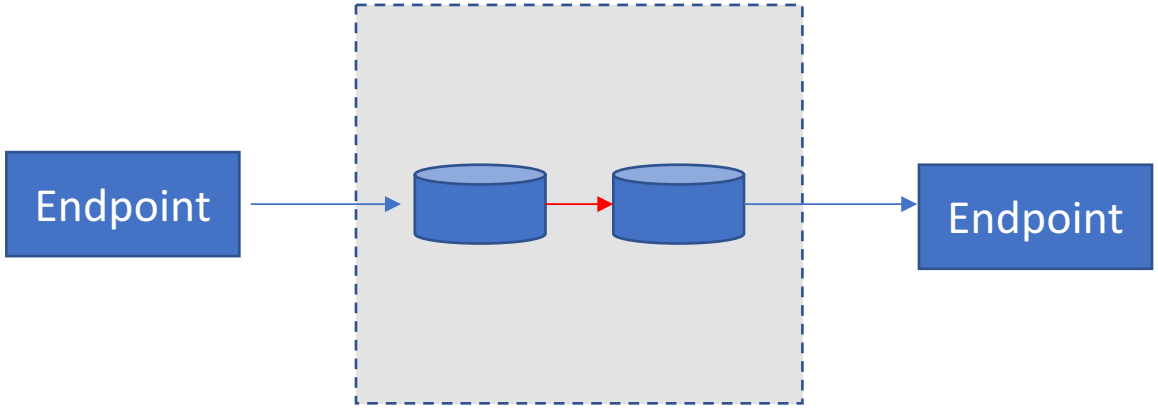
Knowledge

Communication over unreliable channel



- Lacking end-to-end control
- Possibility of drops
  - Results in retransmission unknown to us

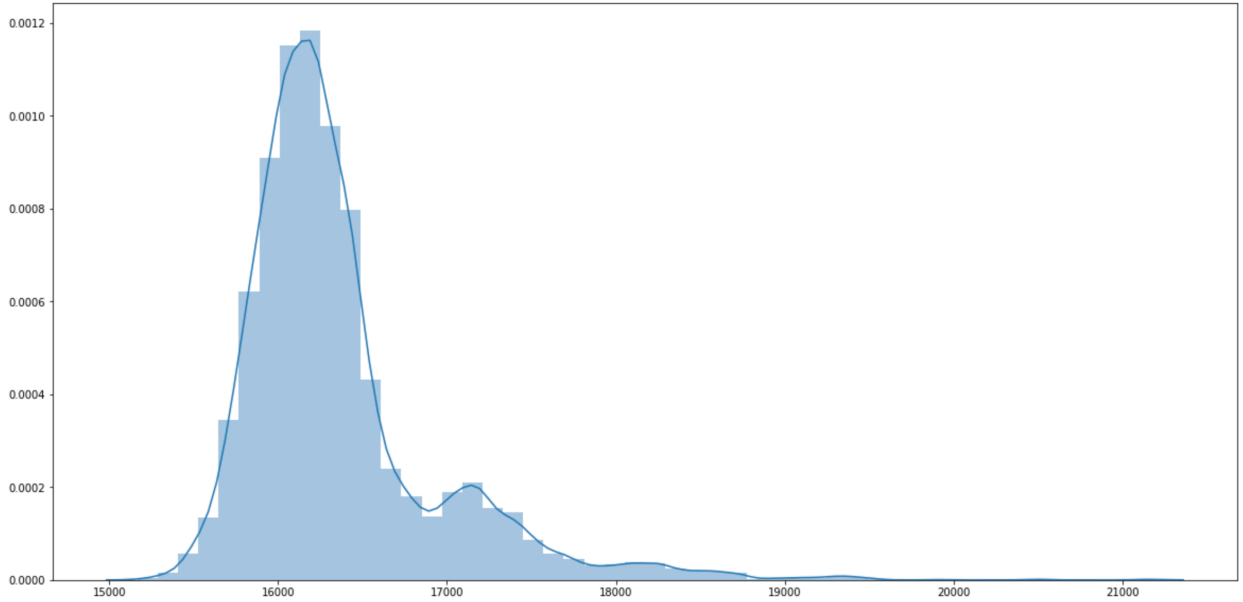
Communication over unreliable channel



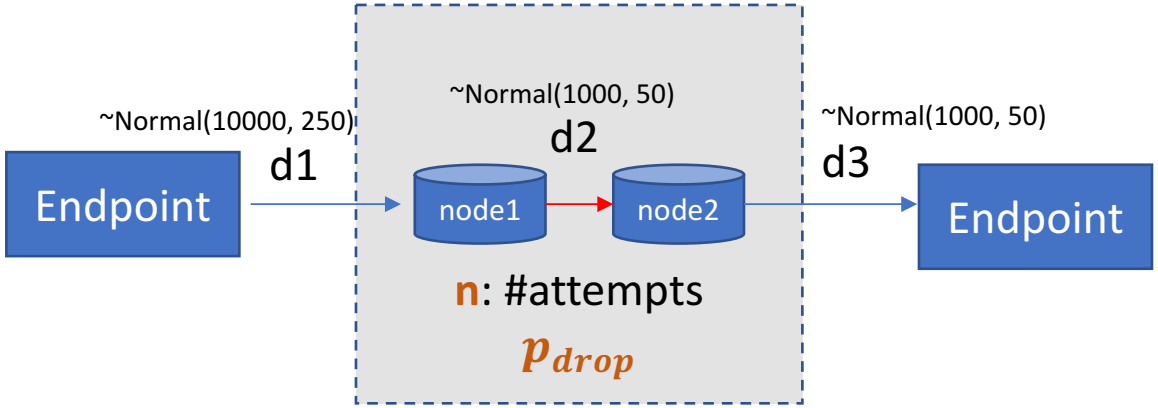
- **Hidden variables:** #drops, **prob(drop)**
- **Data:** one-way delays (OWD)
- **Knowledge:** Distribution of one-way delay between

Data

Distribution of OWD (microseconds)



Knowledge



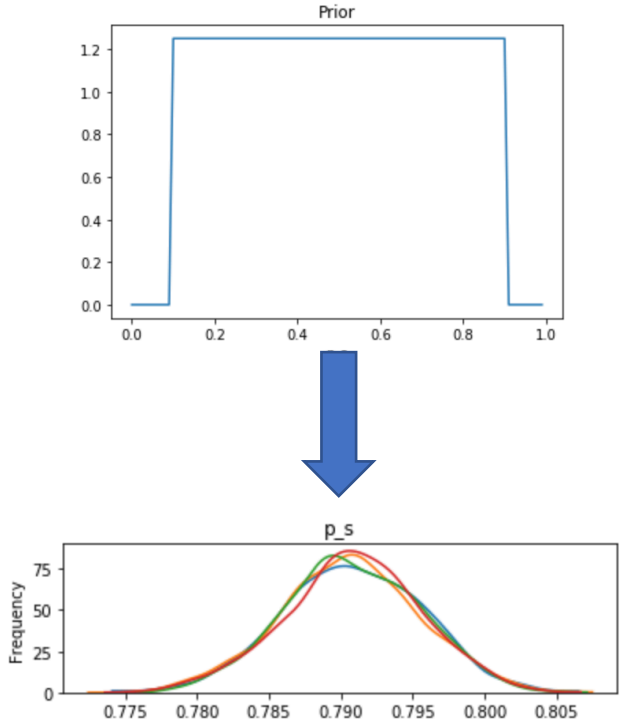
$$OWD = d1 + n \times d2 + d3$$

p_{drop} between 10%-40%

n ~ Geometric(P_s = 1- P_{drop})

Bayesian Inference

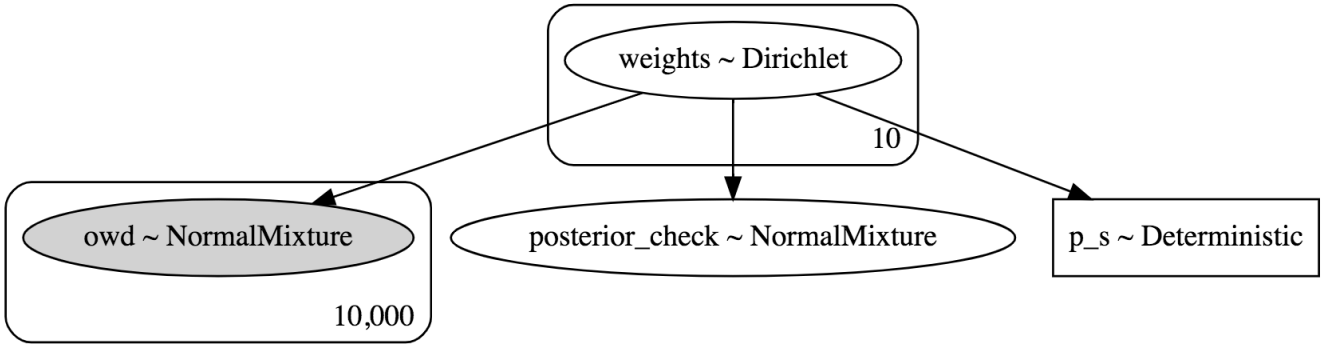
- Updating “belief” with evidence
- Parameters as random variables
  - Constraints in search space
- Requires approximation methods
  - **PyMC3**, Stan, Edward



Salimans, Tim, Diederik Kingma, and Max Welling. "Markov chain monte carlo and variational inference: Bridging the gap." 2015.

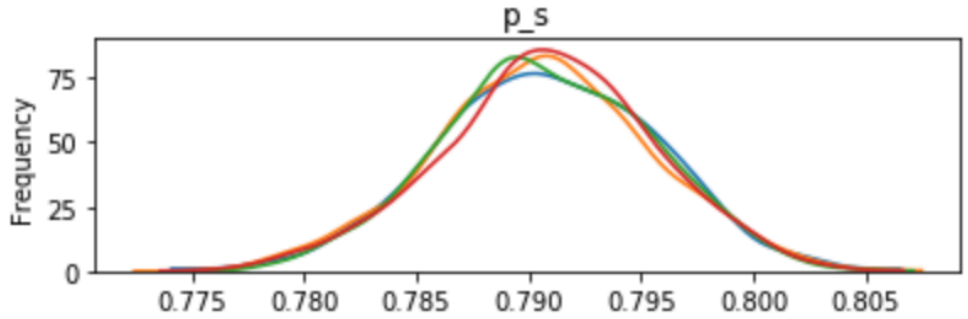
Model using PyMC3

```
weights = pm.Dirichlet('weights', np.ones(max_tries))
owd = pm.NormalMixture(name='owd', mu=MU, sd=STD, w=weights, observed=data)
p_success = pm.Deterministic(name='p_s', var=weights[0])
```



Results

	mean	sd	mc_error	hpd_2.5	hpd_97.5	n_eff	Rhat
p_s	0.790558	0.004911	0.000065	0.781044	0.800114	5084.163069	1.000097



Summary

- Bridging the gap between knowledge and data
- Challenges
  - Debugging
  - Problem formulation
- **PyMC**: https://docs.pymc.io/

Slides/notebook/data: https://github.com/omersyuksel/PyConDE2018

QUESTIONS?

PyMC

Markov-Chain Monte Carlo(MCMC)

Variables:

Random: sampled from a distribution
Deterministic: function of other variables
Observed: data

Finding parameters in MCMC:

Trace
Posterior sample

Posterior samples