

# AMiDST TOOLBOX

Session 3: Coding an Intelligent Fire Detector System

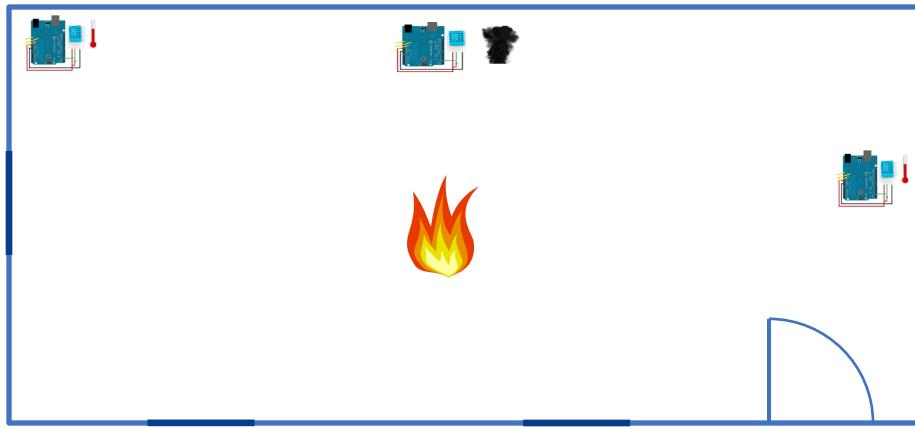
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# Intelligent Fire Detector System



## Fire Detection from smoke and temperature sensors



- Data Collected
  - Tons of observations in normal settings (no fire).
  - No observations in the presence of fire.

- Data Collected on Normal Conditions
  - Noisy Temperature sensor readings ever few milliseconds.
  - Noisy Smoke sensor readings ever few milliseconds.
  - No fire conditions.
- No Data Collected on Fire Conditions
  - Hard to collect data.
  - Lot of prior knowledge.
  - Fire implies much higher temperatures and presence of smoke.

```
1  @relation dataset
2
3  @attribute Fire {0.0, 1.0}
4  @attribute SensorTemp1 real
5  @attribute SensorTemp2 real
6  @attribute SensorSmoke real
7
8
9  @data
10
11 0.0,18.633027714724676,19.400423814001343,-0.02701198878932973
12 0.0,18.298593115433658,20.40726110585825,0.6684046348595264
13 0.0,17.658384956098264,16.8448962949484,0.0841555701844007
14 0.0,18.39203485853405,17.855857296557993,0.12555453999886576
15 0.0,14.680969231785548,15.216145993817902,0.1219859805697214
16 0.0,15.65644513364921,18.900733207095623,0.25791060059142323
17 0.0,16.291732464378637,16.671241527508034,-0.3828607428218462
18 0.0,16.881376100703275,15.96326368868306,-0.754289707629689
19 0.0,18.392756588884964,20.248799056174818,-0.04612653474070432
20 0.0,21.746087507772568,20.029915815684824,-0.6006543157374465
21 0.0,16.88881671759228,17.108335707901386,0.14248132624399362
22 0.0,19.2708098751065,20.04036422884794,-0.08238909529367357
23 0.0,17.82532264741805,20.919998010412705,-0.1583914568166595
24 0.0,15.686577537423716,16.6930158413021,0.08858200127685115
25 0.0,17.635667765053007,17.527333382968898,0.19222365143796472
26 0.0,16.422751277159875,18.746707958578302,-0.3070751462098254
27 0.0,19.842784098779272,16.202081484293643,0.2855195495970611
28 0.0,18.28963876373175,19.606049680224288,0.2053927615899374
29 0.0,19.77427467574227,23.009652346666677,7.536915411803498
30 0.0,17.9229561688799,16.609486486349404,-0.339593744477432
31 0.0,12.360928638409725,15.355162791571903,0.2603535422419724
32 0.0,18.40060066203515,16.36977108609998,0.17271649816102733
33 0.0,18.700830721162834,17.542061776086605,-0.2942513743107443
```

## ■ ARFF Format

- `./datasets/sensorReadings.arff`
- Header detailing state space of the attributes.



# Model Definition



Fire

$Fire \sim Binomial(\rho)$

T1

T2

$T1, T2 \sim Normal(\mu, \sigma)$

## Probabilistic Modeling

Every relevant object is a random variable.

Code: Session3.A\_ModelLearning.java



Fire

$$Fire \sim Binomial(\rho)$$

Temp

$$Temp \sim Normal(\mu, \sigma)$$

T1

T2

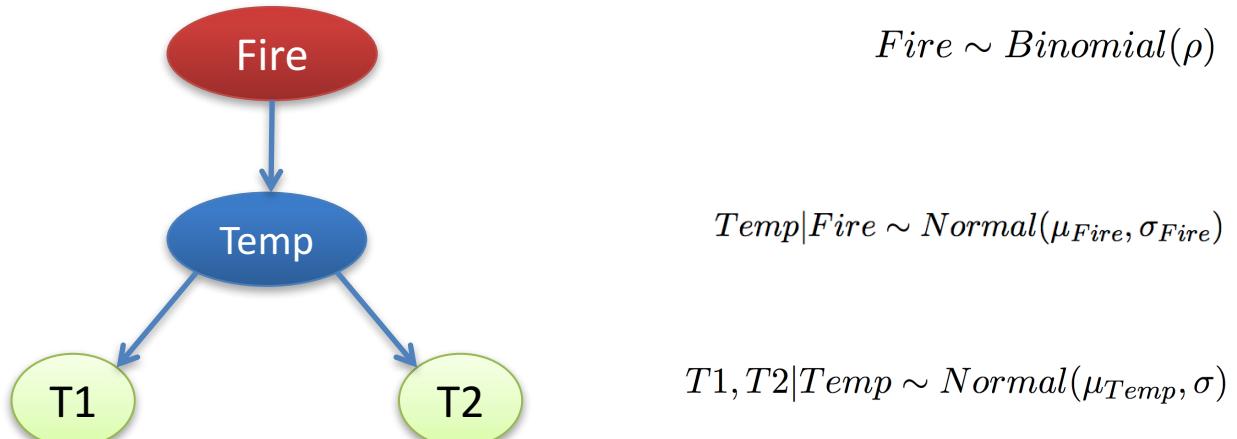
$$T1, T2 \sim Normal(\mu, \sigma)$$

## Latent Variables

Non-observable relevant mechanisms

Code: Session3.A\_ModelLearning.java





## Causal Relationships

They can be extracted for the mechanism itself

Code: Session3.A\_ModelLearning.java



# Learning from Data



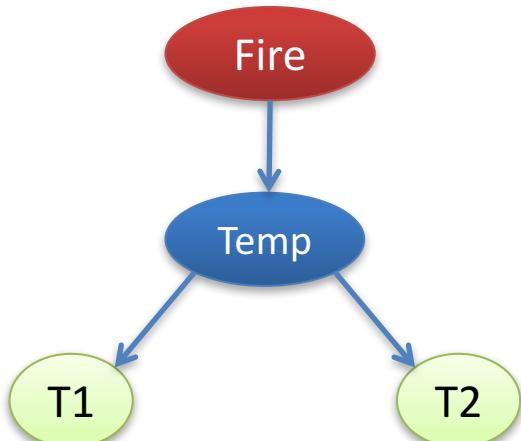
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## ■ ARFF Format

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Code: Session3.A\_ModelLearning.java

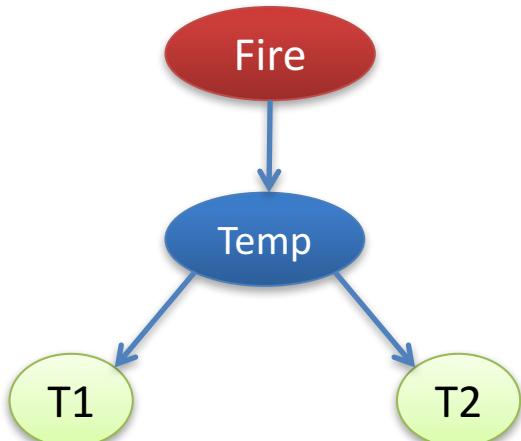




Learn the model from data  
Using Streaming Variational Bayes

Code: Session3.A\_ModelLearning.java

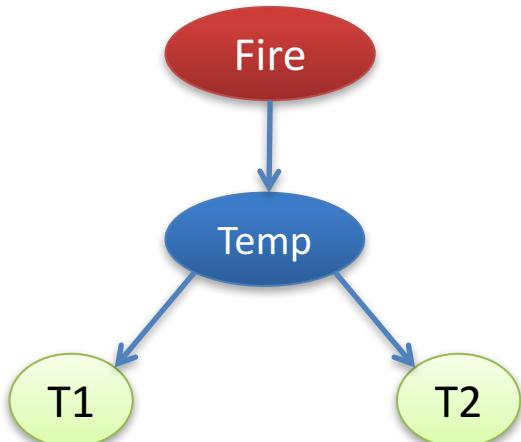




$P(\text{Fire})$  follows a Multinomial  
[ 0.99800796812749, 0.00199203187250996 ]

Code: Session3.A\_ModelLearning.java



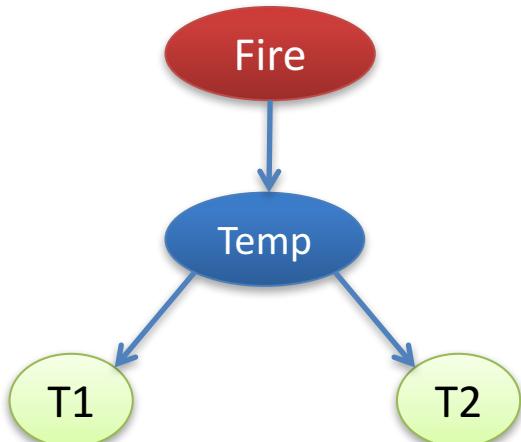


$P(\text{Temperature} \mid \text{Fire})$  follows a Normal|Multinomial

```
Normal [ mu = 17.850398684425084, var = 2.7261903668047873 ] | {Fire = 0}  
Normal [ mu = 0.0, var = 1.0 ] | {Fire = 1}
```

Code: Session3.A\_ModelLearning.java

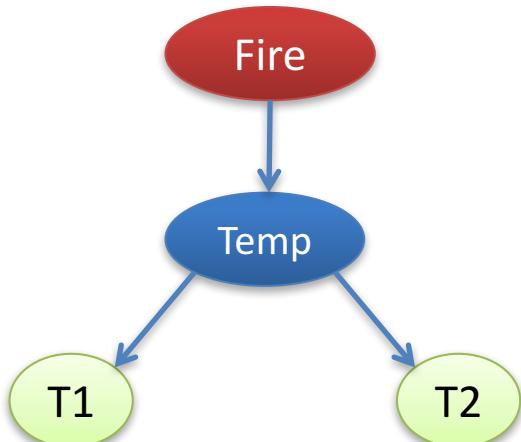




```
P(SensorTemp1 | Temperature) follows a Normal|Normal  
[ alpha = 0.0, beta1 = 1.0, var = 2.1200596403156617 ]  
P(SensorTemp2 | Temperature) follows a Normal|Normal  
[ alpha = 0.0, beta1 = 1.0, var = 2.157733884167721 ]
```

Code: Session3.A\_ModelLearning.java





$P(\text{SensorSmoke} \mid \text{Smoke})$  follows a Normal|Multinomial

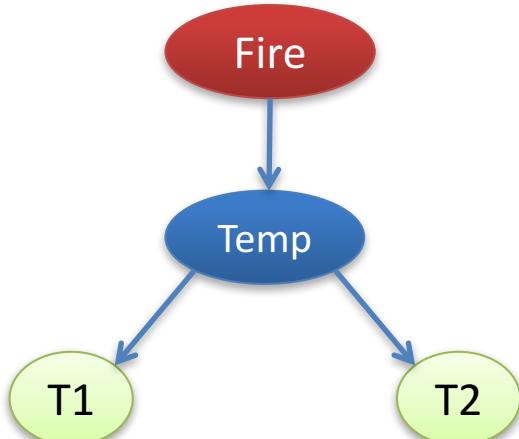
Normal [ mu = -0.0038624730690733047, var = 0.09751495591088893 ] | {Smoke = 0}

Normal [ mu = 4.791637077454833, var = 3.583493438495509 ] | {Smoke = 1}

Code: Session3.A\_ModelLearning.java

# Integrating Expert Knowledge





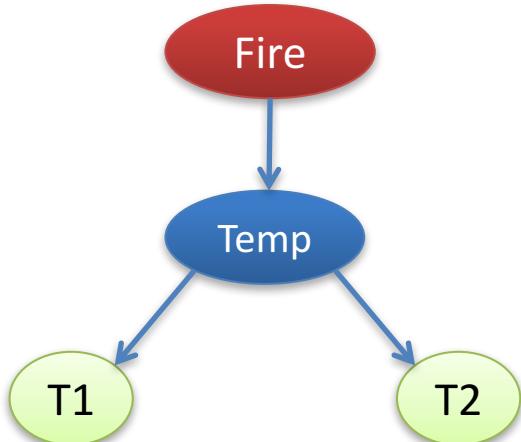
Modify the non-learnt conditional probabilities

Code: Session3.B\_AddExpertKnowledge.java



# Making Predictions

Code: Session3.C\_ModelInference.java



$$p(Fire = True | t_1, t_2)$$

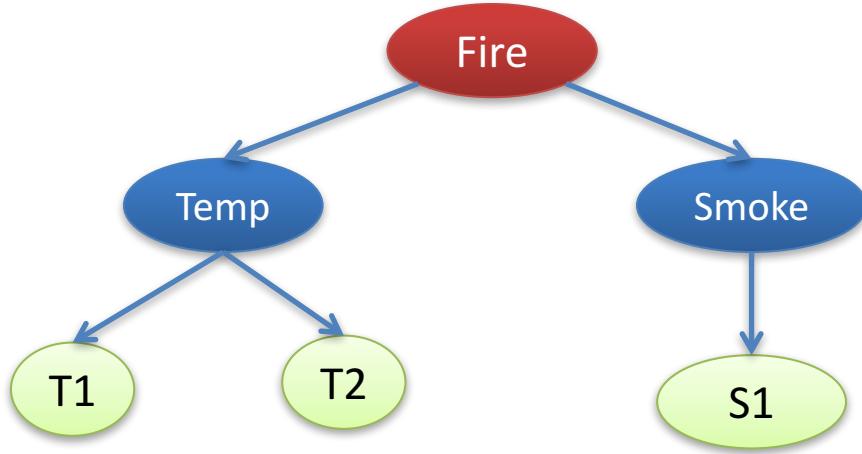
Query the Model



# Code Exercise

Code: Session3.C\_ModelInference.java

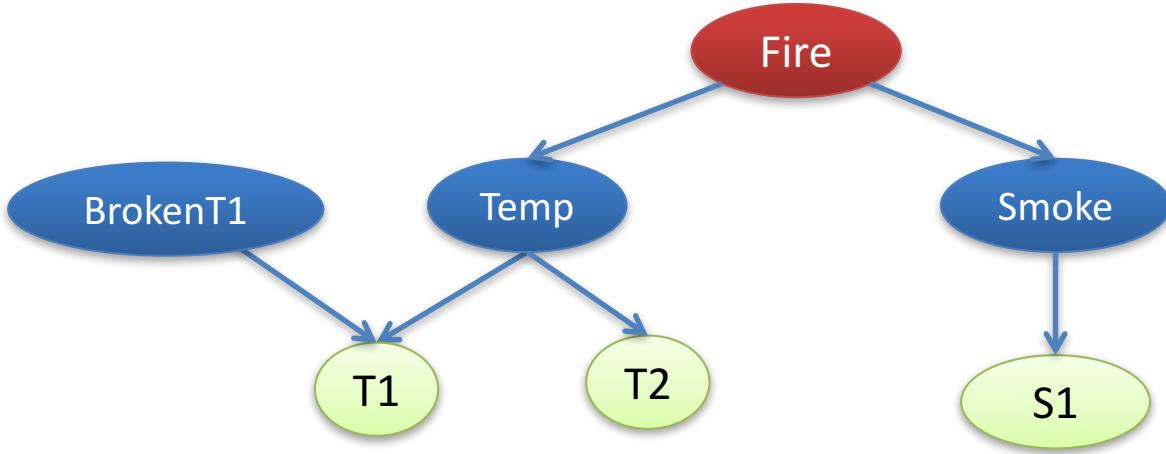




## What about Smoke Sensor?

Introduce Smoke Sensor into the model

# EXAMPLE OF PGMS



Extend the model

# Thanks for your attention

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