DISASTER DETECTION AND RECOVERY

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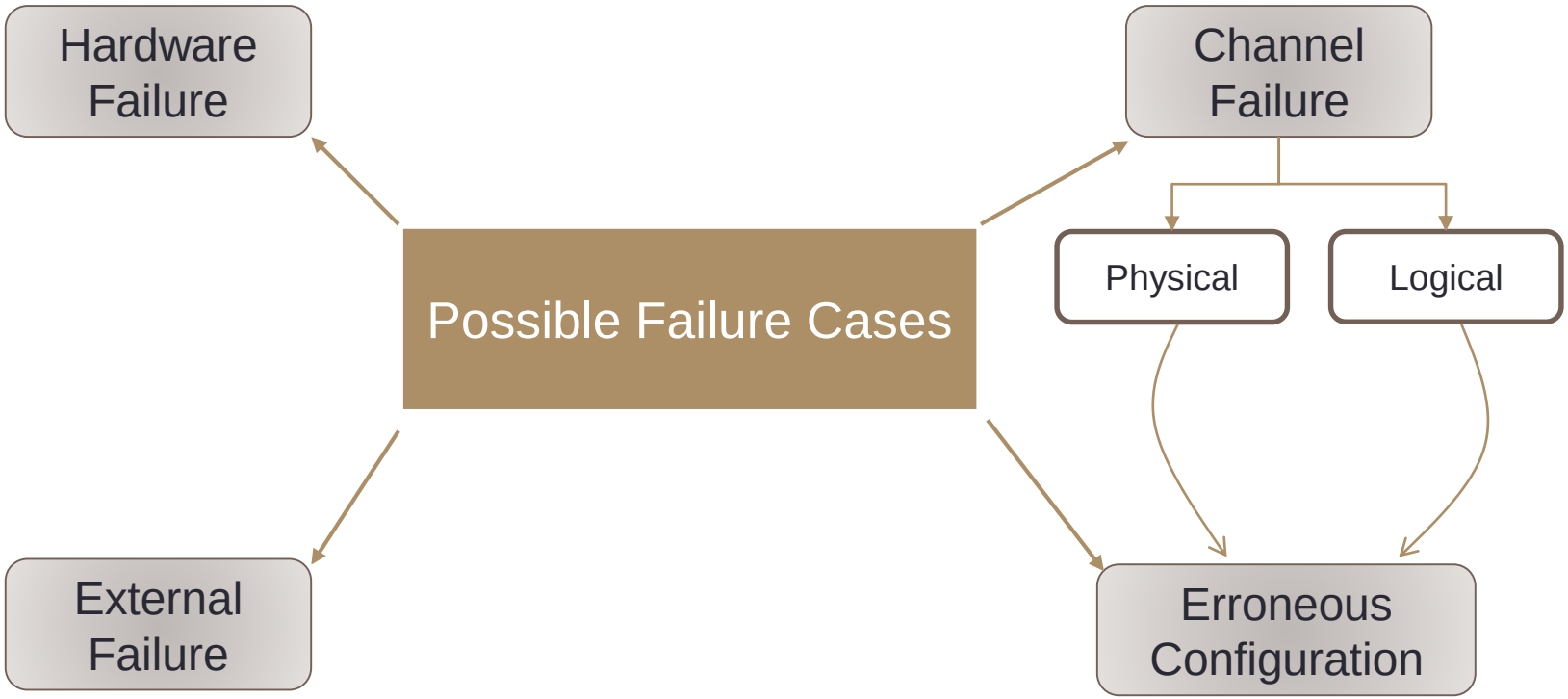
Outline

1. Introduction
2. Paper 1: *An approach for network outage detection from drive-testing databases*
3. Paper 2: *Classification-based approach for cell outage detection in self-healing heterogeneous networks*
4. Proposed Scheme

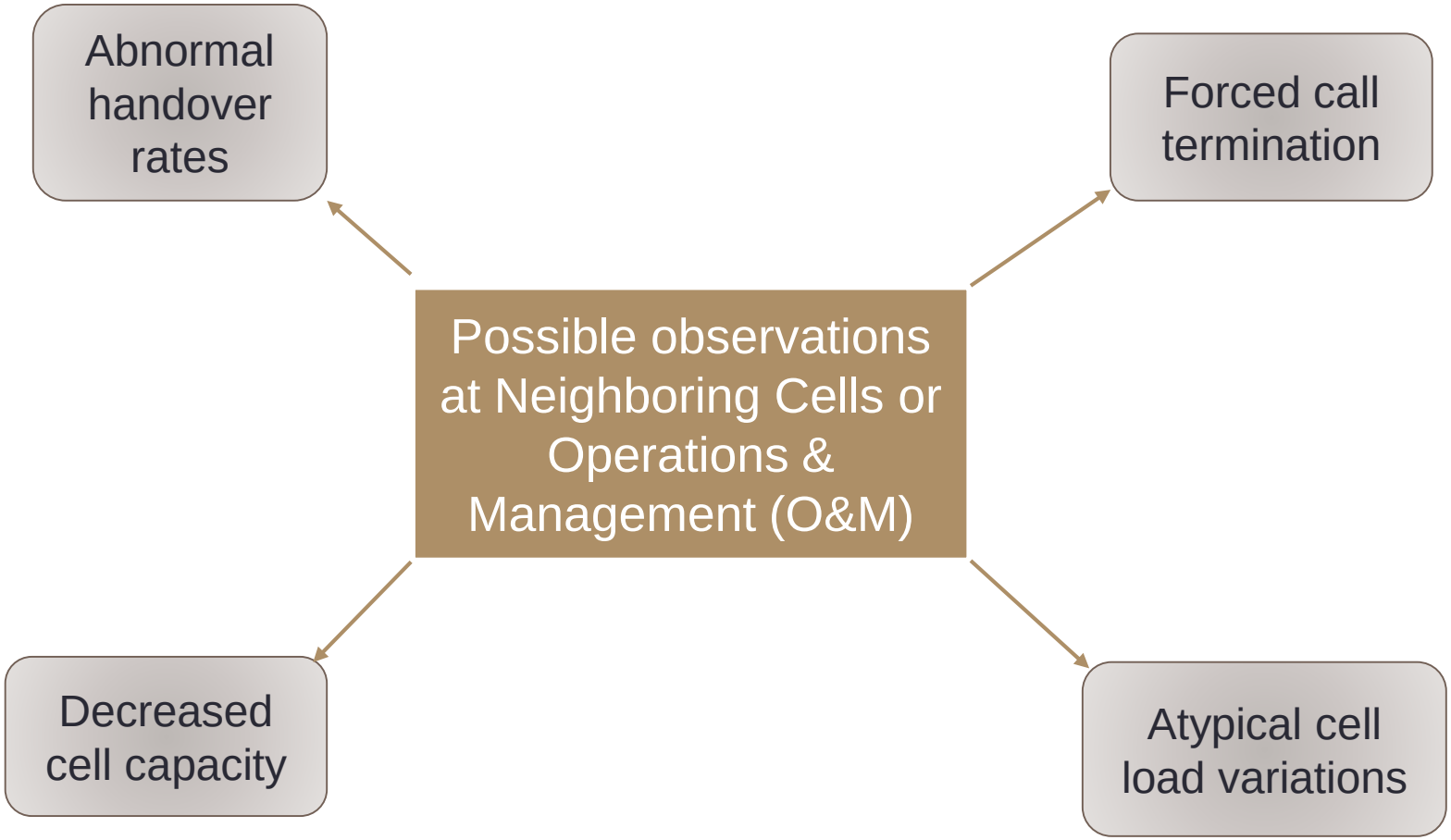
Self-Healing

Use cases	Cell Outage Detection	Cell Outage Compensation
	LTE Release 10	
Proposed Solutions	Bayesian analysis	(trigger re-configuration setting)
	Visibility graph (generated in neighbor cell list)	
	Trigger Conditions of Self Healing (TCoSH)	

What causes cell outage?



What indicates cell outage?



What motivates COD?

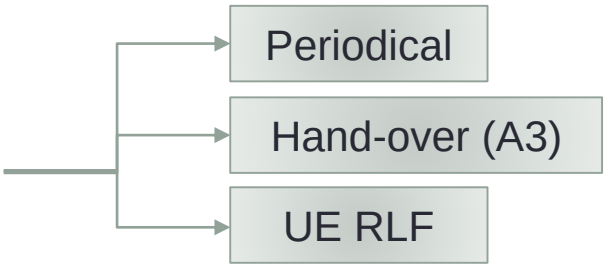
- Currently, discovery and identification of errors involves considerable manual analysis and may require unplanned site visits → Cost!

- If cell outage is not compensated for earlier:
  - QoS decreases
    (customer complaints → reliability drops)
  - Neighboring cells suffer heavier load than usual

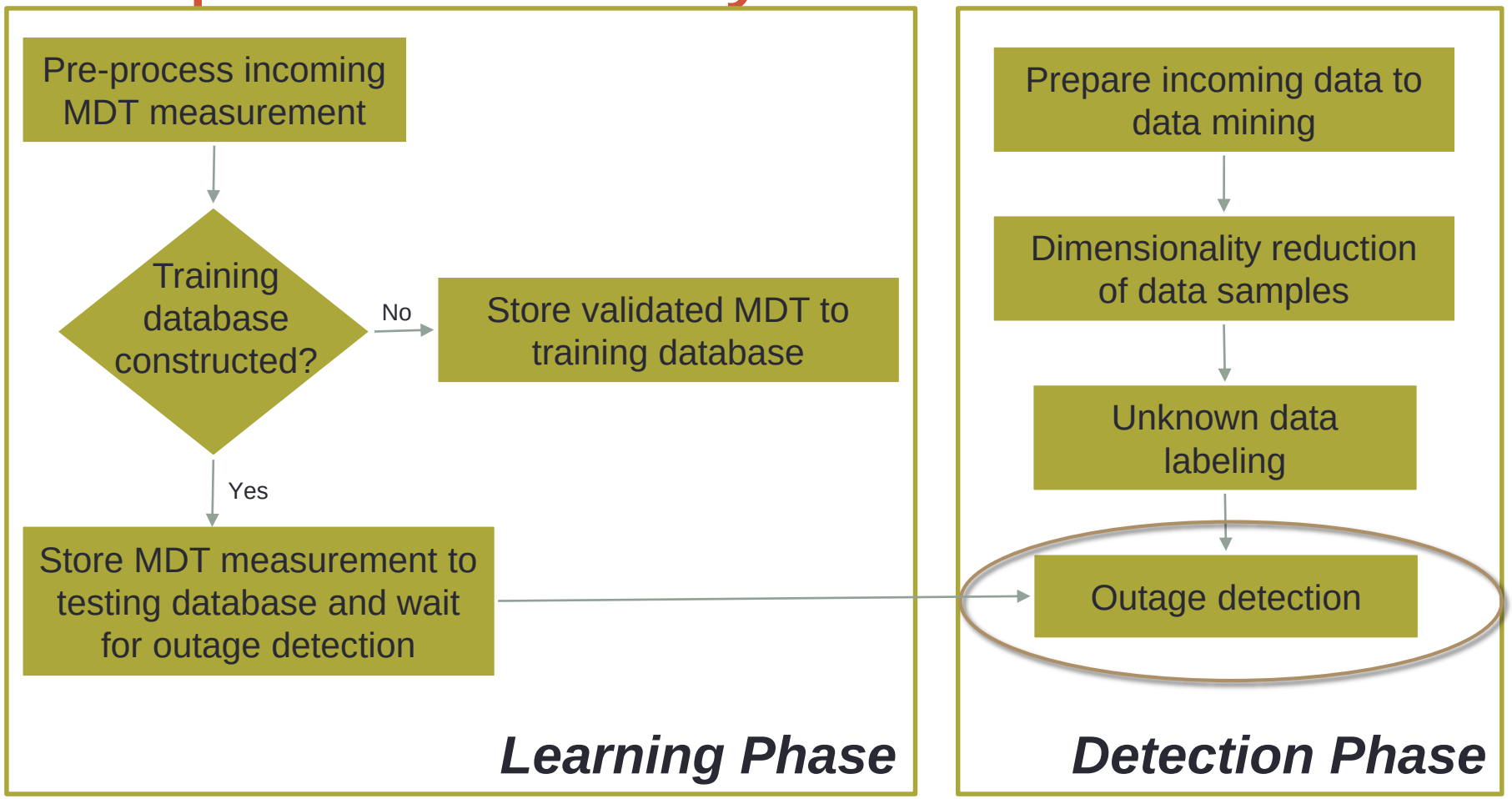
Paper 1 Summary

- Minimization of Driving Tests (MDT) use case: define a set of measurements and their reporting procedures which would help to collect coverage-related information from UEs

- MDT Measurement Samples:
  1. Latitude/Longitude
  2. Time Information
  3. Serving Cell Radio Measurements (RSRP/RSRQ)
  4. 3 Best Neighboring Cells Radio Measurements
  5. Serving Cell Wideband CQI
  6. Available uplink transmission power
  7. ** **Label** is appended to the report



Paper 1 Summary



Paper 1 Summary

- Outage Detection
  1. Time domain: compare target eNB behavior in time to the behavior observed earlier
  2. Base station domain: compare target eNB behavior to its neighboring eNBs

- Assumption: When the network is in outage, many periodical MDT measurements should be similar to the RLF samples

- if $(z_e = \frac{|x_e - \mu_x|}{\sigma_x}) > 1$, eNB is in outage

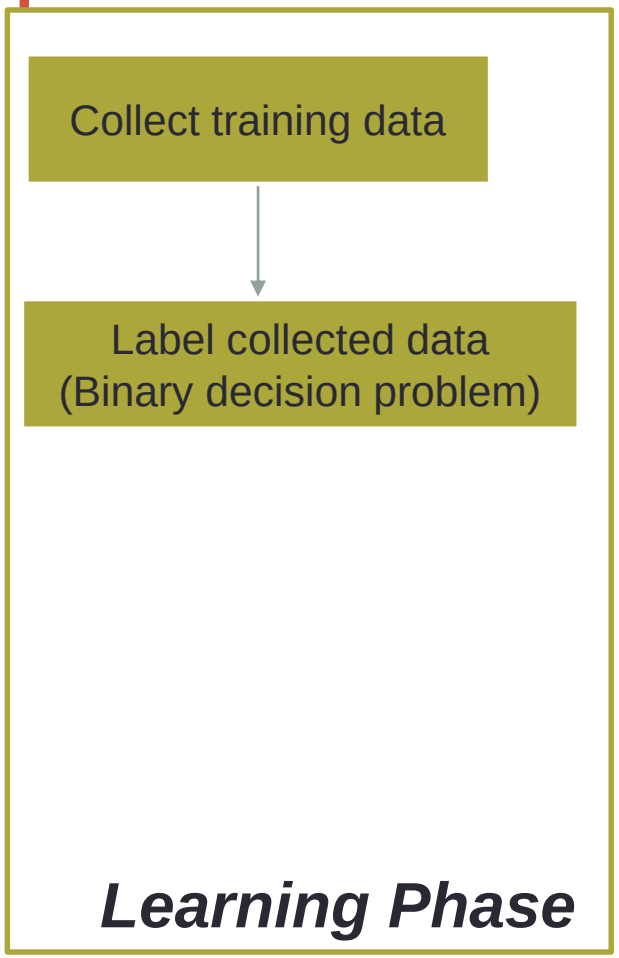
Paper 2 Summary

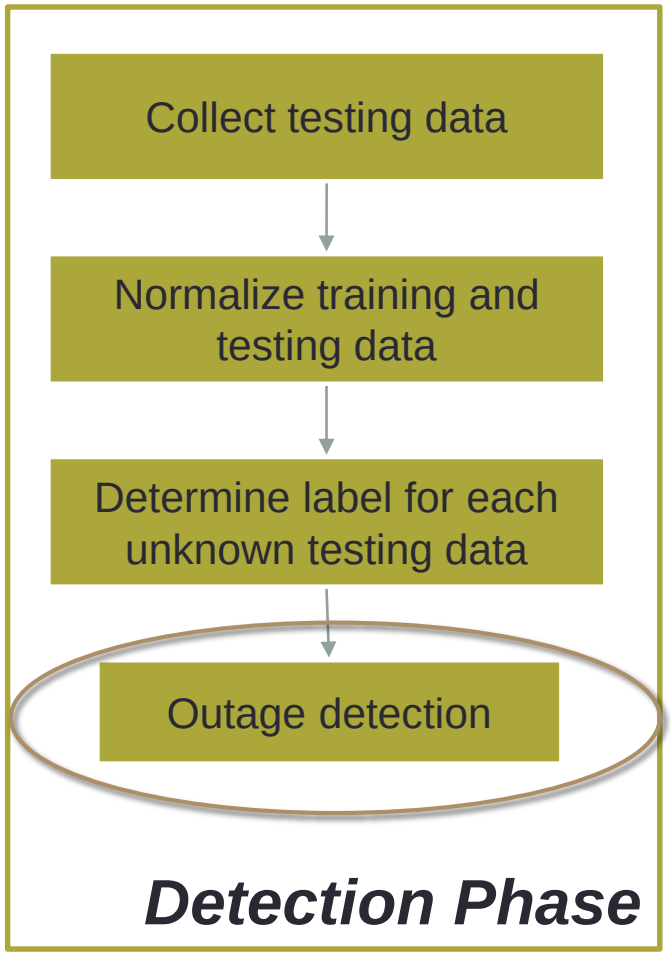
- During normal operational phase, UEs from macro and pico cells report their available measurements, labelled as **periodical** or **RLF-like**

- Data part for mining algorithm:
  1. Serving Cell RSRP & RSRQ
  2. Maximum Neighboring Cell RSRP & RSRQ

  - Assume that training data set is denoted as
    T = $\{t_1, t_2, \cdots, t_i, \cdots, t_m\}$,
    where t_i= $\{RSRP_s, RSRP_n, SINR_s, SINR_n\}$

Paper 2 Summary





Paper 2 Summary

- Assumption: When the network is in outage, many sampled data should be similar to the RLF samples

- F-measurement

  if $(f_{measurement}(k,l) = \frac{2 \times precision(k,l) \times recall(k,l)}{precision(k,l) + recall(k,l)})$ is close to pre-specified threshold (1 for macro, 0.5 for pico), eNB is in outage.

$$precision(k,l) = \frac{n_{kl}}{n_k}$$

$$recall(k,l) = \frac{n_{kl}}{n_l}$$

- Z-score

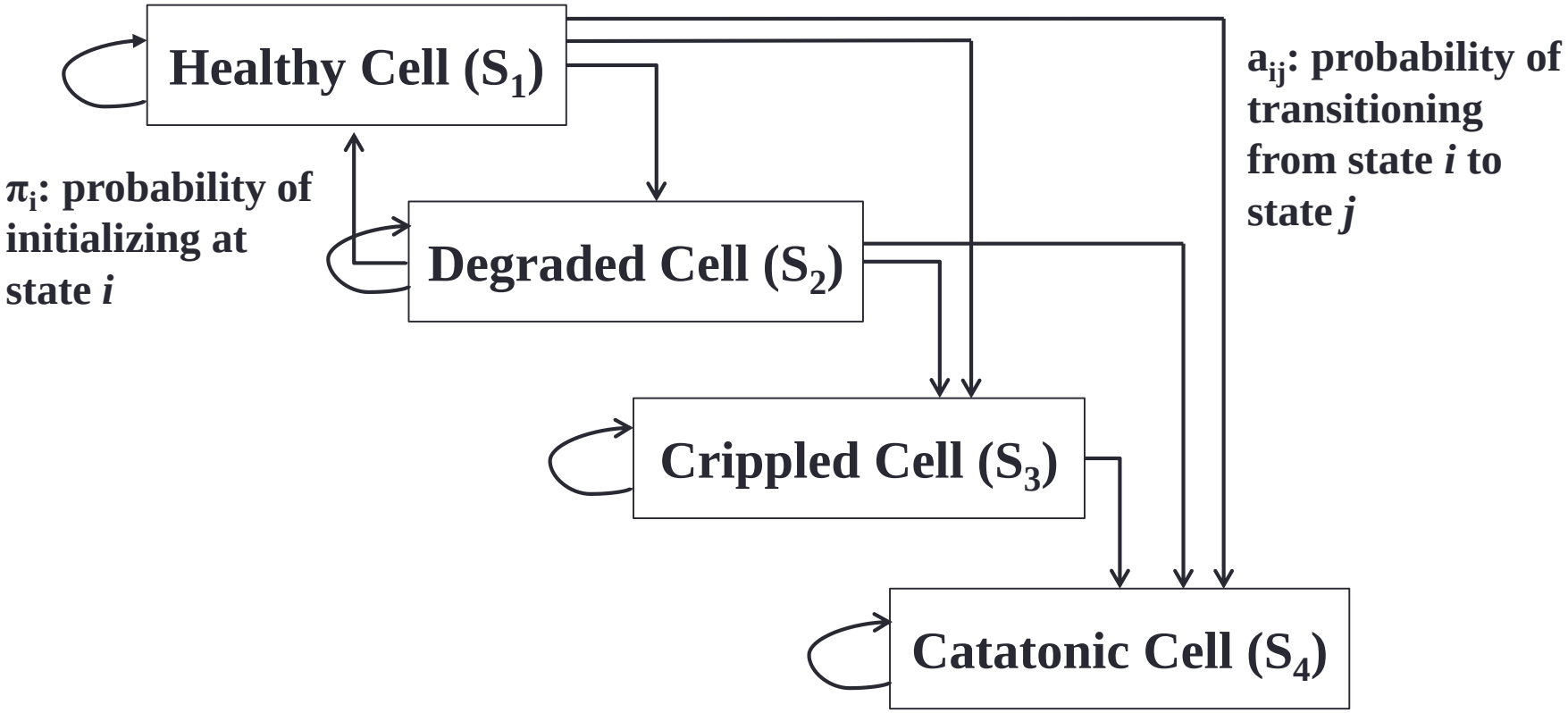
  if $(z_k = \frac{|n_{kl} - \mu|}{\sigma})$> 1, eNB is in outage.

Sleeping Cells

- In “Method of monitoring wireless network performance” patent (2006), sleeping cells have been categorized into three different kinds:
  1. Degraded cell
  2. Crippled cell
  3. Catatonic cell

- In “N-gram analysis for sleeping cell detection in LTE networks” ICASSP paper (2013), the authors state that “*There exist a vague classification of degraded cells depending on how much they affect the network operation*”.

Sleeping Cells (Markov Chain)

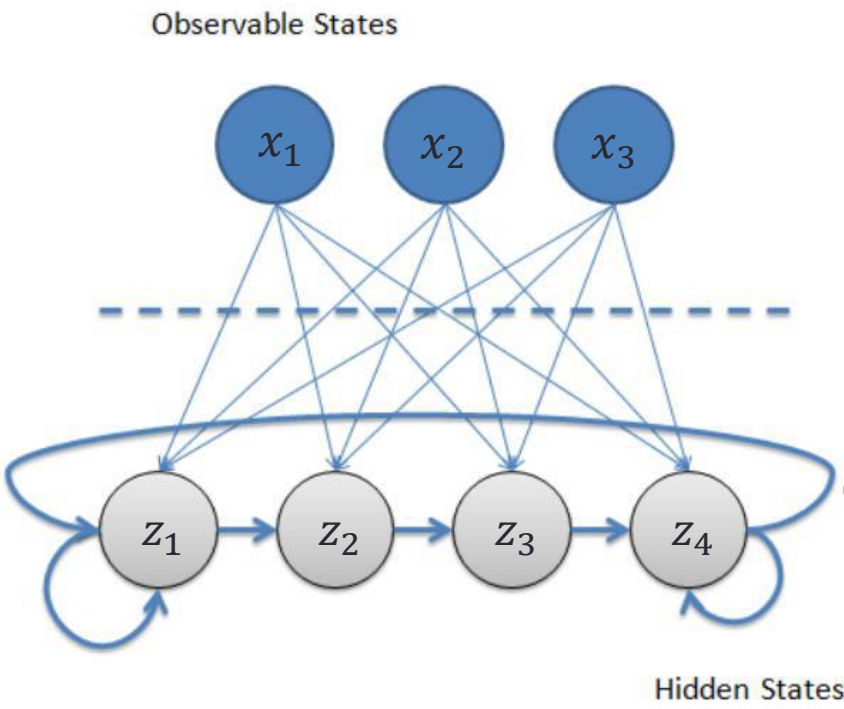


Sleeping Cells (Markov Chain)

Problems:

1. How to calculate p(i, j)?
2. How to calculate q(i)?
3. How do we know which state that the cell is in?
   a) How to differentiate the three different types of sleeping cells?

Hidden Markov Model



The connections between the hidden states and the observable states represent the probability of generating a particular observed state given that the Markov process is in a particular hidden state.

Modeled by a simple first order Markov process (Slide #18)

Hidden Markov Model

- Goal: Compute p(state of cell|observations)

Transition Matrix

	Healthy	Degraded	Crippled	Catatonic
Healthy	$p_{H,H}$	$p_{H,D}$	$p_{H,C}$	$p_{H,T}$
Degraded	NA	$p_{D,D}$	$p_{D,C}$	$p_{D,T}$
Crippled	NA	NA	$p_{C,C}$	$p_{C,T}$
Catatonic	NA	NA	NA	$p_{T,T}$

Emission Matrix

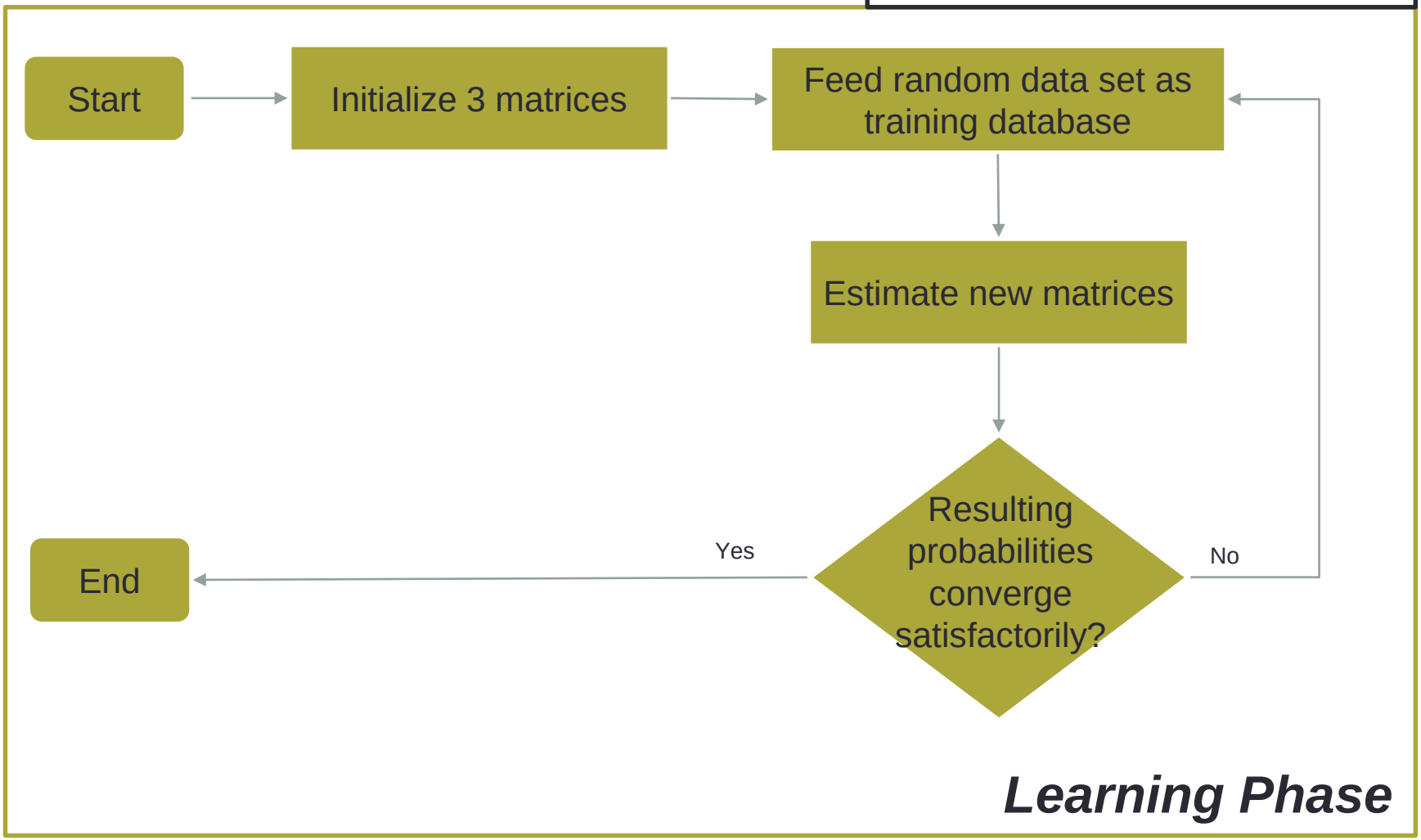
	x_1	……	x_n
Healthy	p(x_1|H)	……	p(x_n|H)
Degraded	p(x_1|D)	……	p(x_n|D)
Crippled	p(x_1|C)	……	p(x_n|C)
Catatonic	p(x_1|T)	……	p(x_n|T)

InitialMatrix

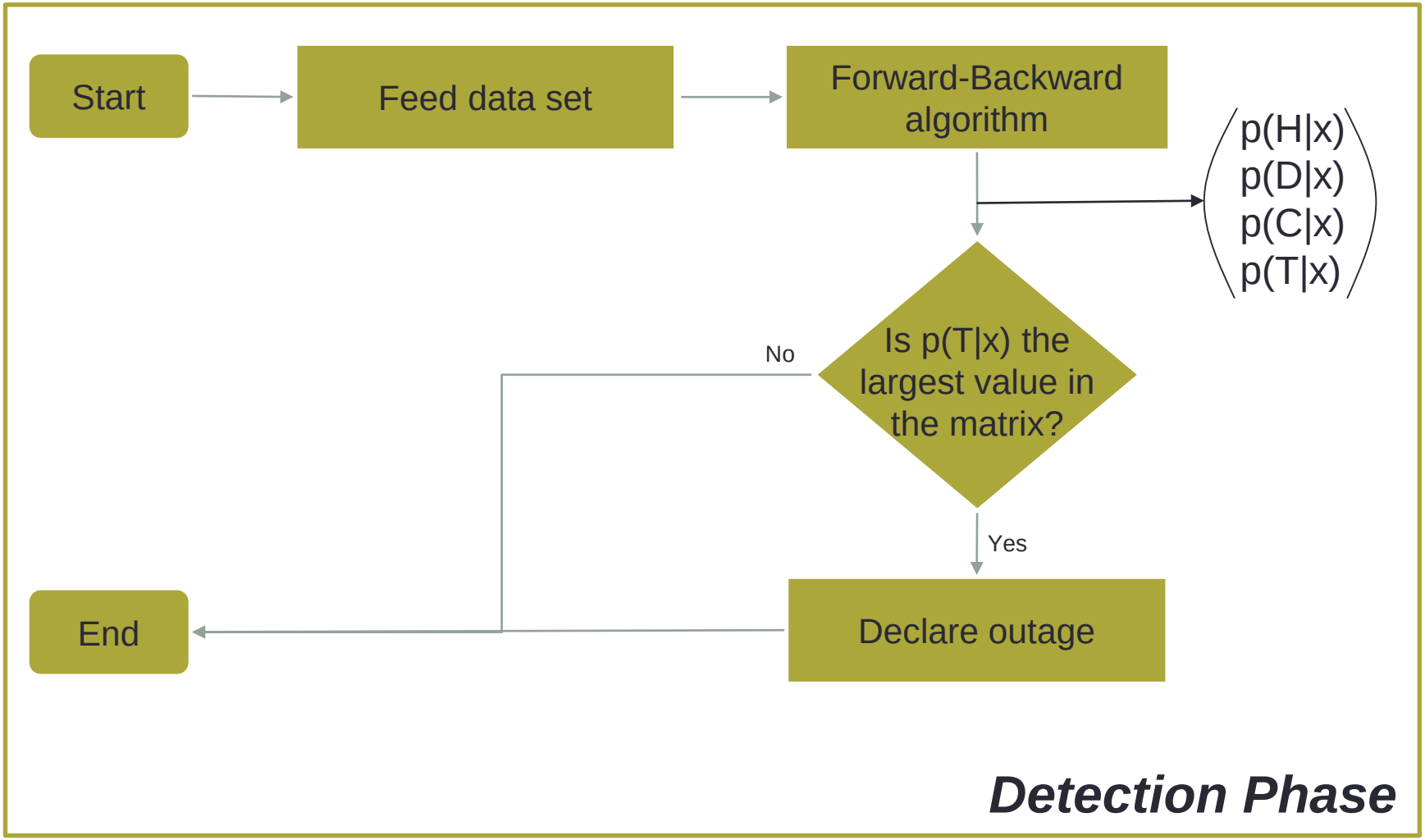
Healthy	p_H
Degraded	p_D
Crippled	p_C
Catatonic	p_T

Flowchart

Baum-Welch Algorithm & Expectation Maximization



Flowchart


Start
Feed data set
Forward-Backward algorithm
p(H|x)
p(D|x)
p(C|x)
p(T|x)
Is p(T|x) the largest value in the matrix?
No
Yes
Declare outage
End
Detection Phase

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- Chernogorov, F., Ristaniemi, T., Brigatti, K., & Chernov, S. (2013, May). “N-gram analysis for sleeping cell detection in LTE networks”, In 2013 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 4439-4443).

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Thank You