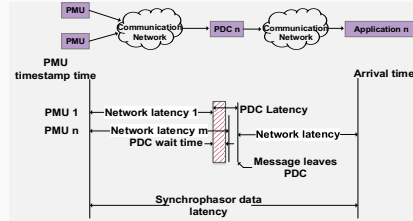# DELAY AWARE MEASUREMENTS GATHERING IN WAMS COMMUNICATION NETWORK

Reem Kateb, Parisa Akaber, Mosaddek Tushar, Mourad Debbabi, Chadi Assi
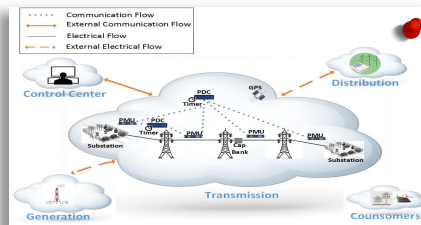Concordia Institute for Information System Engineering

Motivation

- The increase deployment of IT technologies in WAMS increase the vulnerabilities to cyber attack
- Acting based on delayed or missed measurement degrade the performance of WAMS applications

Objective

- Investigate delay attack on WAMS and its impact on real-time applications
- A tree construction model that satisfies delay requirements under delay attacks

PDC Timer
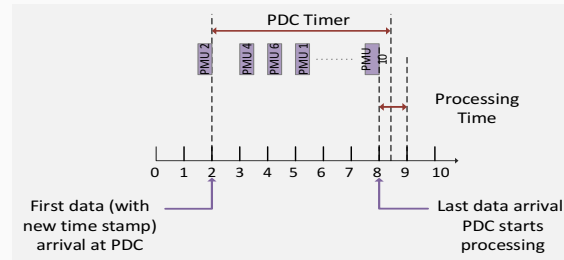
- The PDC timer ensures the freshness of measurements in case of delay.
- The timer introduces the problem of incompleteness.

Mathematical Model

A measurement from a PMU is valid if:
1. It satisfies the end-to-end delay
2. Arrive before the expiration of the PDC timer

The objective is to minimize the number of invalid measurements within a PDC timer

$$\beta_{u_i c} = \begin{cases} 1 \ if \ measuremnt \ u_i \ is \ valid \\ 0 \ otherwise \end{cases}$$

$$\text{Min} \sum_{u_i} \beta_{u_i c} \ \forall \ c \ \in \ N_c$$

Where c is a PDC in the set of PDCs N_c

Numerical Results

- Consider the different IEEE test systems
- Comparison with shortest path tree

Test System	Trees	30 ms		40 ms		50 ms		60 ms	
		#Invalid	#Links	#Invalid	#Links	#Invalid	#Links	#Invalid	#Links
IEEE 14-bus	Proposed Model	0	0%	9	0	0%	8	0	0%	0	0%	9
	Shortest Path	4	40%	8	3	30%	8	1	1-	8	1	10%	8
IEEE 24-bus	Proposed Model	1	5%	14	0	0%	12	0	0%	12	0	0%	12
	Shortest Path	5	23%	12	3	14%	12	2	9%	12	0	0%	12
IEEE 30-bus	Proposed Model	0	0%	16	0	0%	16	0	0%	16	0	0%	16
	Shortest Path	5	13%	15	4	10%	15	1	3%	15	1	3%	15

Table: Number and Percentage of "Invalid" Measurements and The Average Number of Links Per Tree

- Analyze the impact of delay attacks on the number of "invalid" measurements
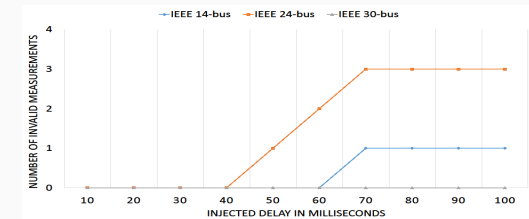
Conclusion

- A mathematical model for PMU communication routing
- The objective is to minimize the number of invalid measurements due to delay attack
- The proposed model manages to find trees that minimize the impact of delay attack while satisfying real-time requirements