Exponential stability almost surely for WADC with intermittent information transmission using stochastic time scale

CURENT

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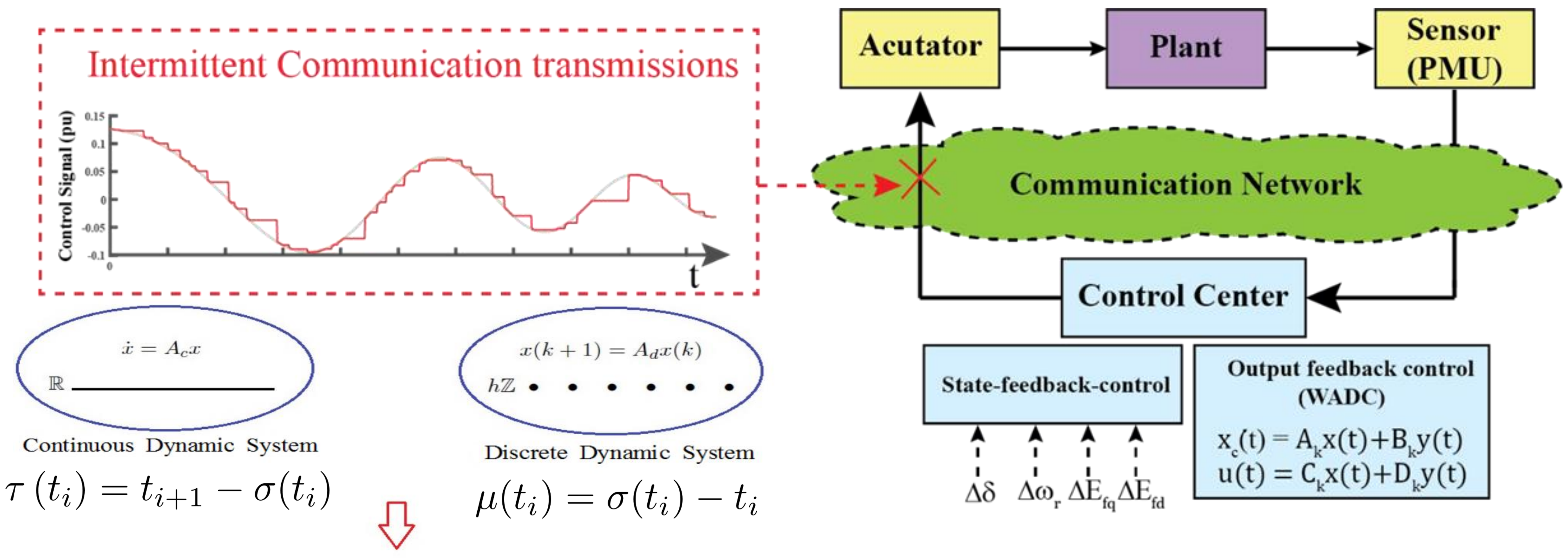
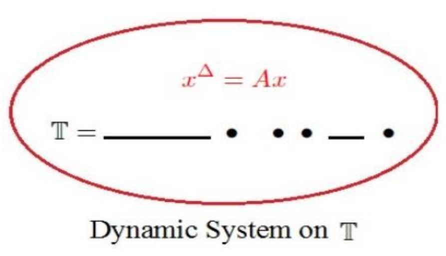
1 MOTIVATION, PROPOSED CONCEPT AND FRAMEWORK





$$x^{\Delta}(t) = \begin{cases} A_c\, x(t) & \text{for } t \in \cup_{k=0}^{\infty}[\sigma(t_k), t_{k+1}[, \quad (\sigma(t_0) = t_0) \\ A_d\, x(t) & \text{for } t \in \cup_{k=0}^{\infty}\{t_{k+1}\} \end{cases}$$

$$x(t) = e^{A_c(t-\sigma(t_k))}(I + \mu(t_k)A_d)e^{A_c(t_k - \sigma(t_{k-1}))}\dots(I + \mu(t_1)A_d)e^{A_c t_1}\, x_0.$$

Fig.1 Control block diagram of the feedback loop with connecting physical network through communication network which introduces delays

Modern power grids are relying more on closed-loop controls with signals passed through communication networks. If any interruption of information transmission occurs, the system will act as a discrete time subsystem. Here for a wide-area damping control (WADC) example, an actuator or measurement signal will hold (remain constant) during a random time interval. Our stability condition allows us to better capture the systems hybrid behavior with less computational effort and greater precision.

2 STABILITY CONDITION: EXPONENTIAL ALMOST SURELY REGION

- Switched system with static-feedback control law

$$x^{\Delta}(t) = \begin{cases} (A + BK)x(t), & t \in \cup_{i=0}^{\infty}[\sigma(t_i), t_{i+1}) \\ \left(\dfrac{e^{A\mu(t_i)} - I}{\mu(t_i)}\right)\left(I + A^{-1}BK\right)x(t), & t \in \cup_{i=0}^{\infty}\{t_{i+1}\} \end{cases}$$

- Stability condition:

$$\mathbb{E}[\Re(\lambda_j)\tau_k] + \mathbb{E}[\log(|1 + \mu_k \lambda_j|)] < 0, \quad \forall 1 \le j \le n.$$

- Switched system with dynamic output feedback control law

$$\hat{x}^{\Delta}(t) = \begin{cases} \begin{bmatrix} A + BD_kC & BC_k \\ B_kC & A_k \end{bmatrix}\hat{x}(t), \\ t \in \cup_{i=0}^{\infty}[\sigma(t_i), t_{i+1}) \\ \dfrac{\left(e^{\begin{bmatrix} A & BC_k \\ 0 & A_k \end{bmatrix}\mu(t)} - I\right)}{\mu(t)} \times \\ \left[I + \begin{bmatrix} A & BC_k \\ 0 & A_k \end{bmatrix}^{-1}\begin{bmatrix} BD_kC & 0 \\ B_kC & 0 \end{bmatrix}\right]\hat{x}(t), \\ t \in \cup_{i=0}^{\infty}\{t_{i+1}\} \end{cases}$$

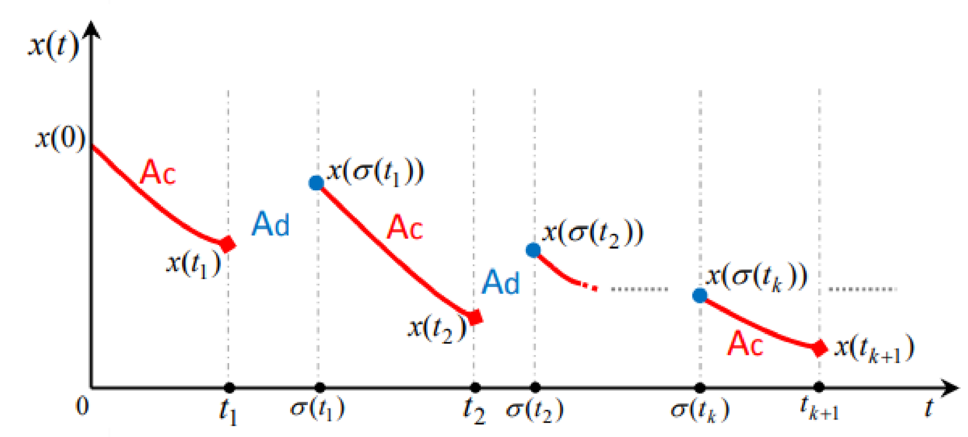
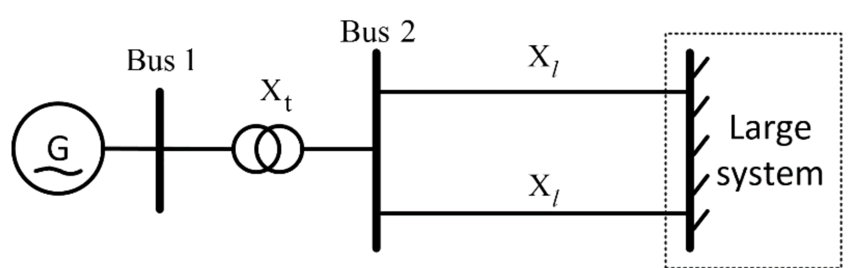
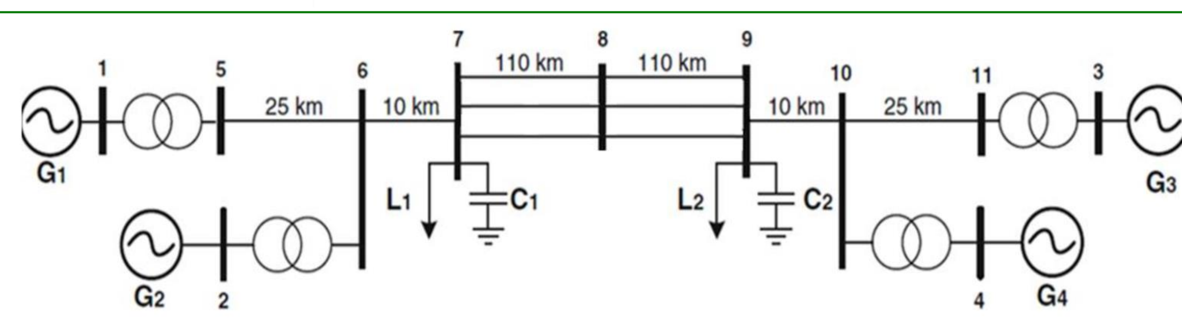


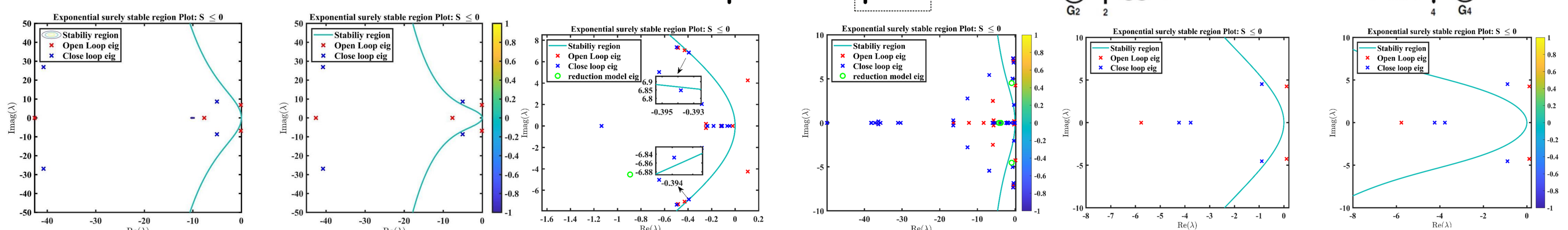
Fig. 2 switched system on non-uniformed time domain

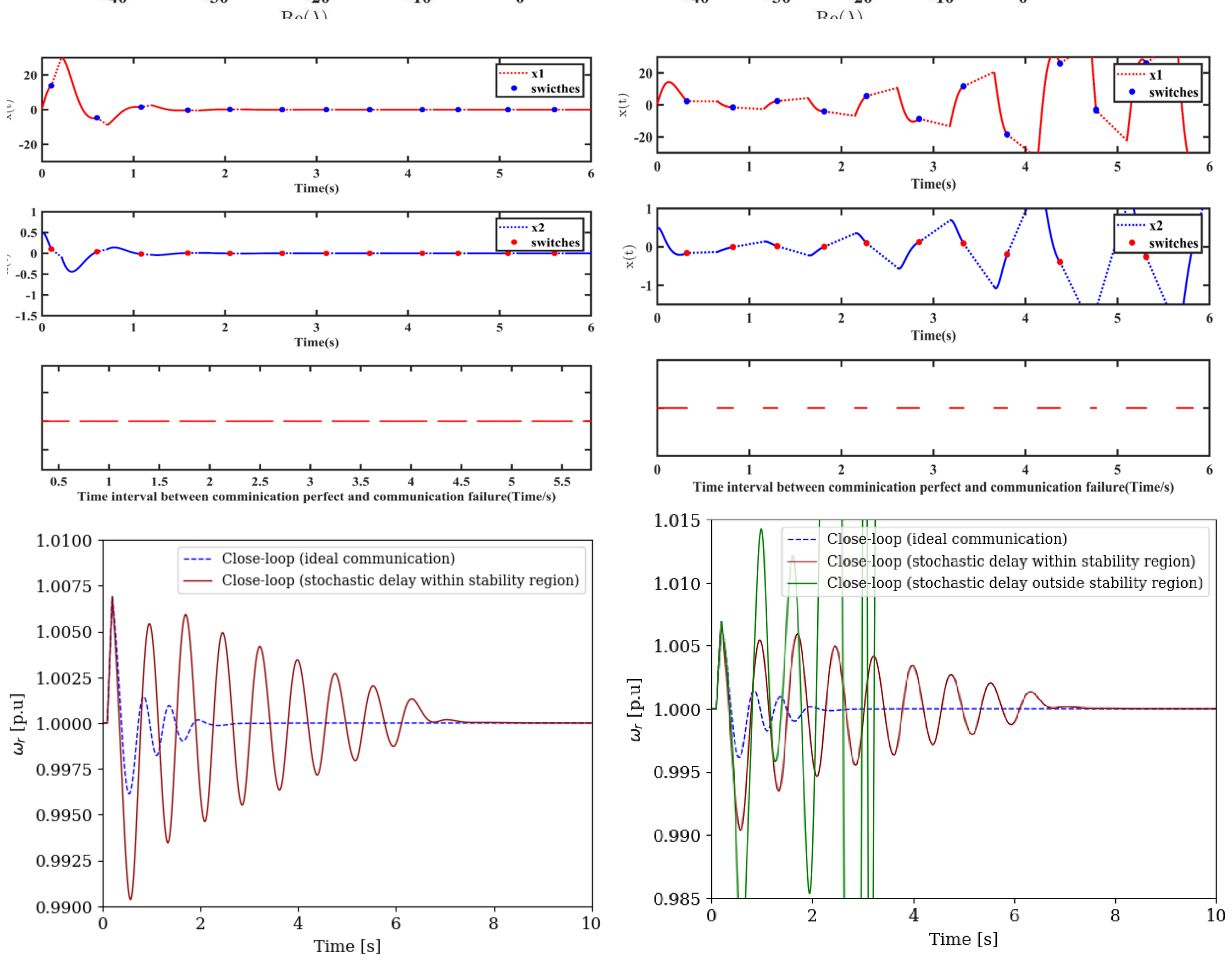
3 CASE STUDY

- Study systems: SMIB/Kundur Two Area

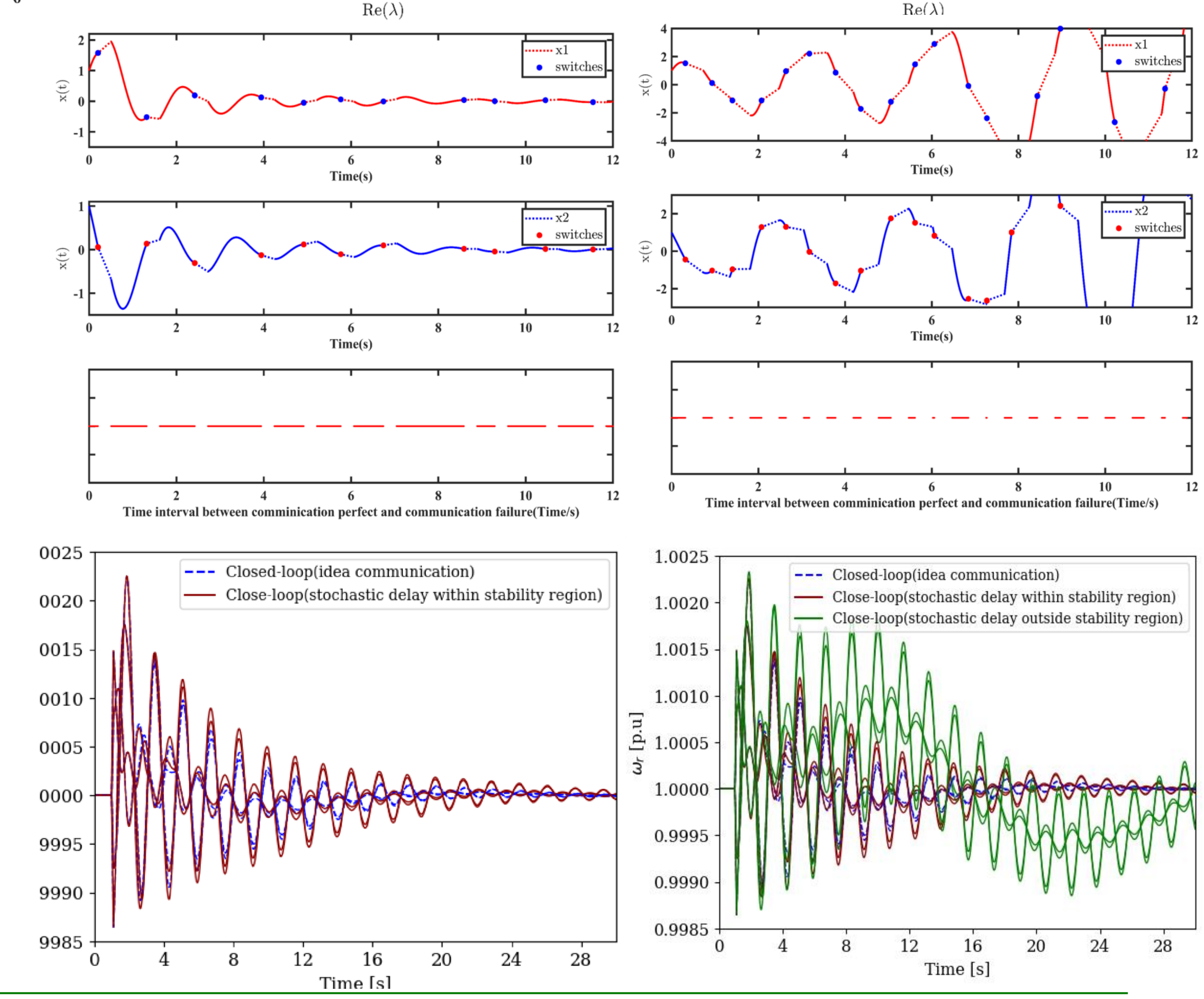








- Region of exponential stability almost surely by following different distributions.
- State trajectories in case of stochastic time delay.
- Maximum allowable time delay: Case1(0.3246s), Case2(1.2635s)
- Dwell time delay: Case1(0.21s), Case2(0.61s)



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