



清华大学



Beyond Sigmoids: The NetTide Model for Social Network Growth, and Its Applications

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What is the growth pattern of social networks, like Facebook and WeChat?

The problem

• $n(t) = ?$ $e(t) = ?$

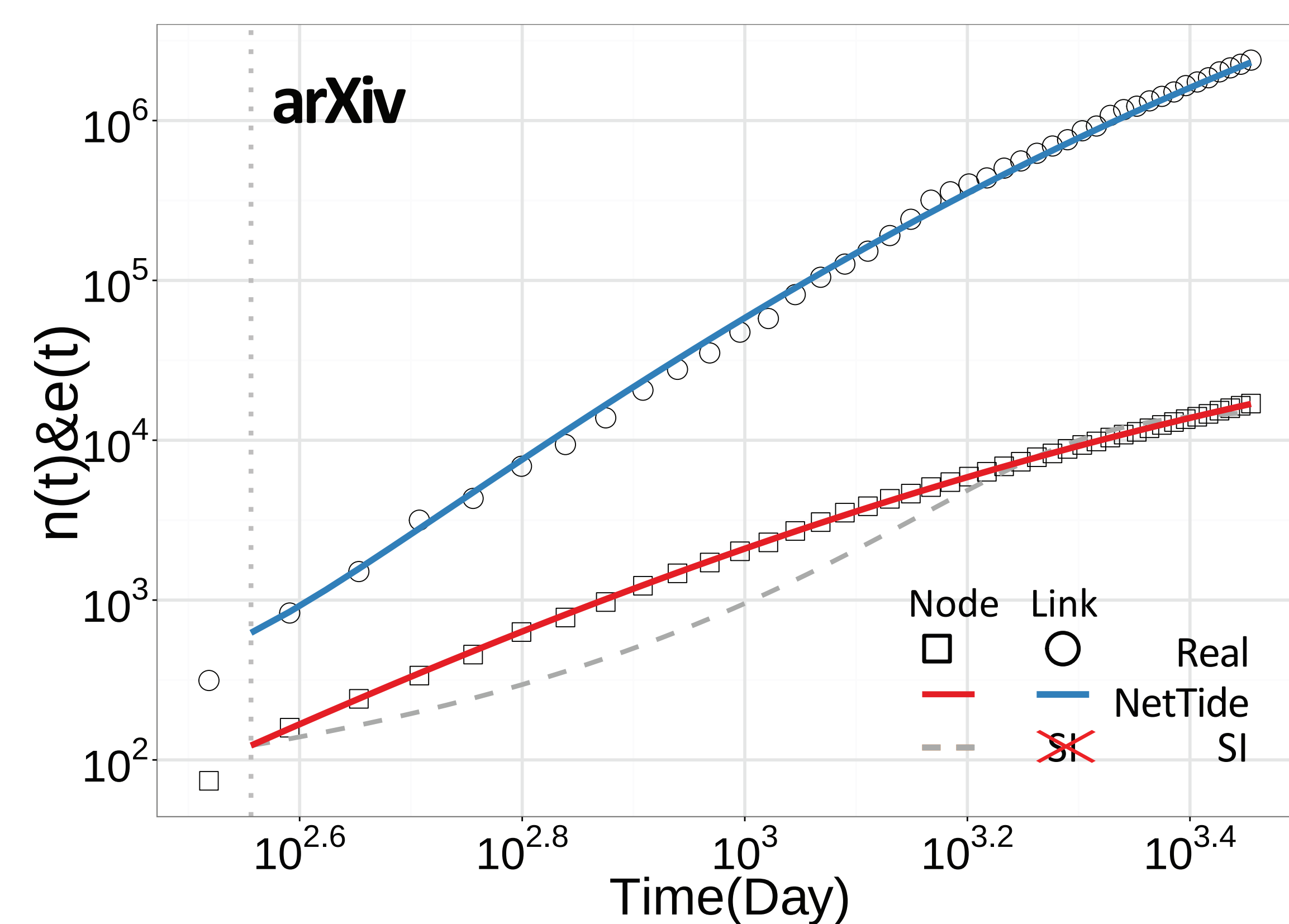
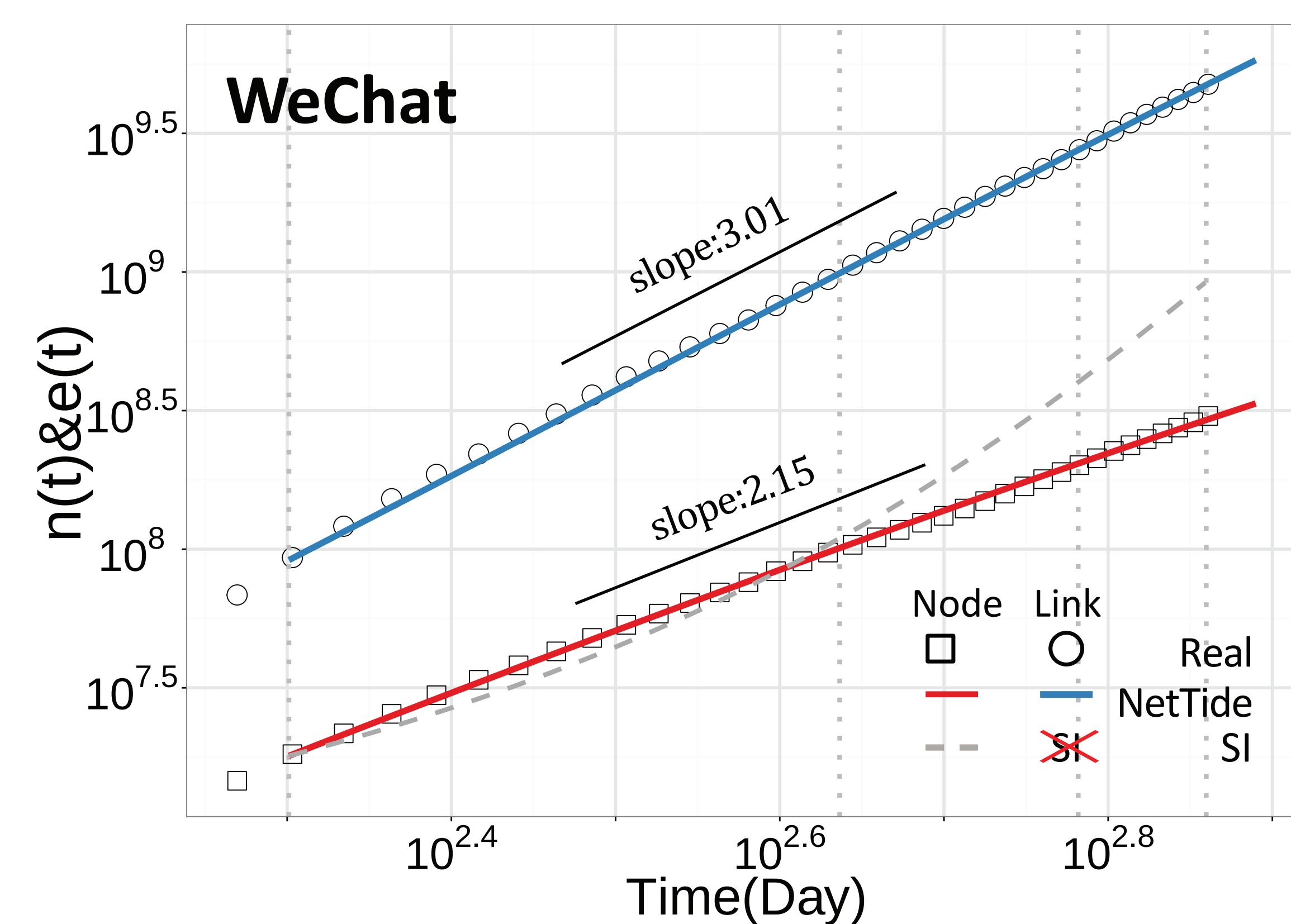
The datasets

• WeChat (300 million nodes, 4.75 billion links), etc

The findings

• Power law growth

• NetTide model

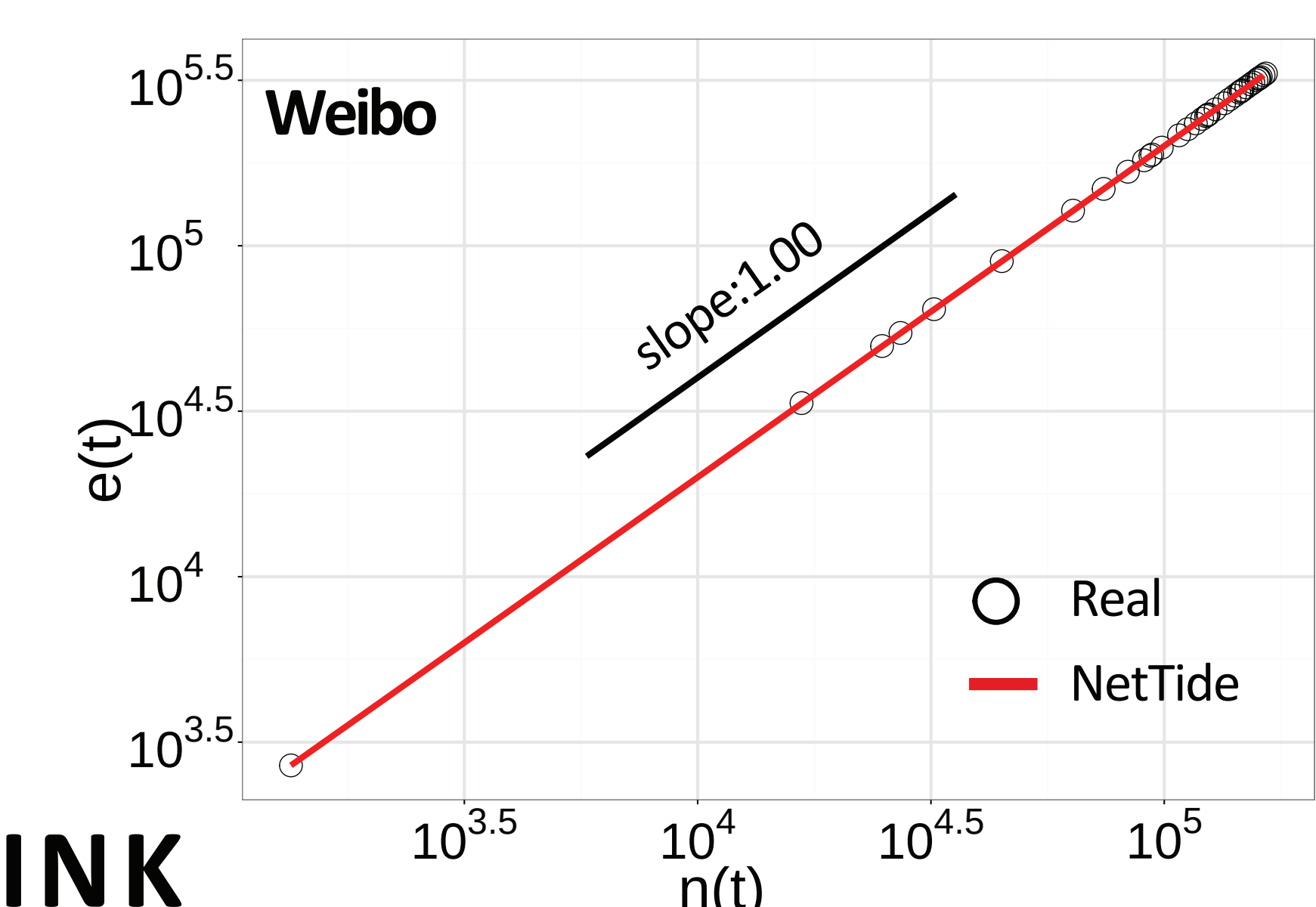
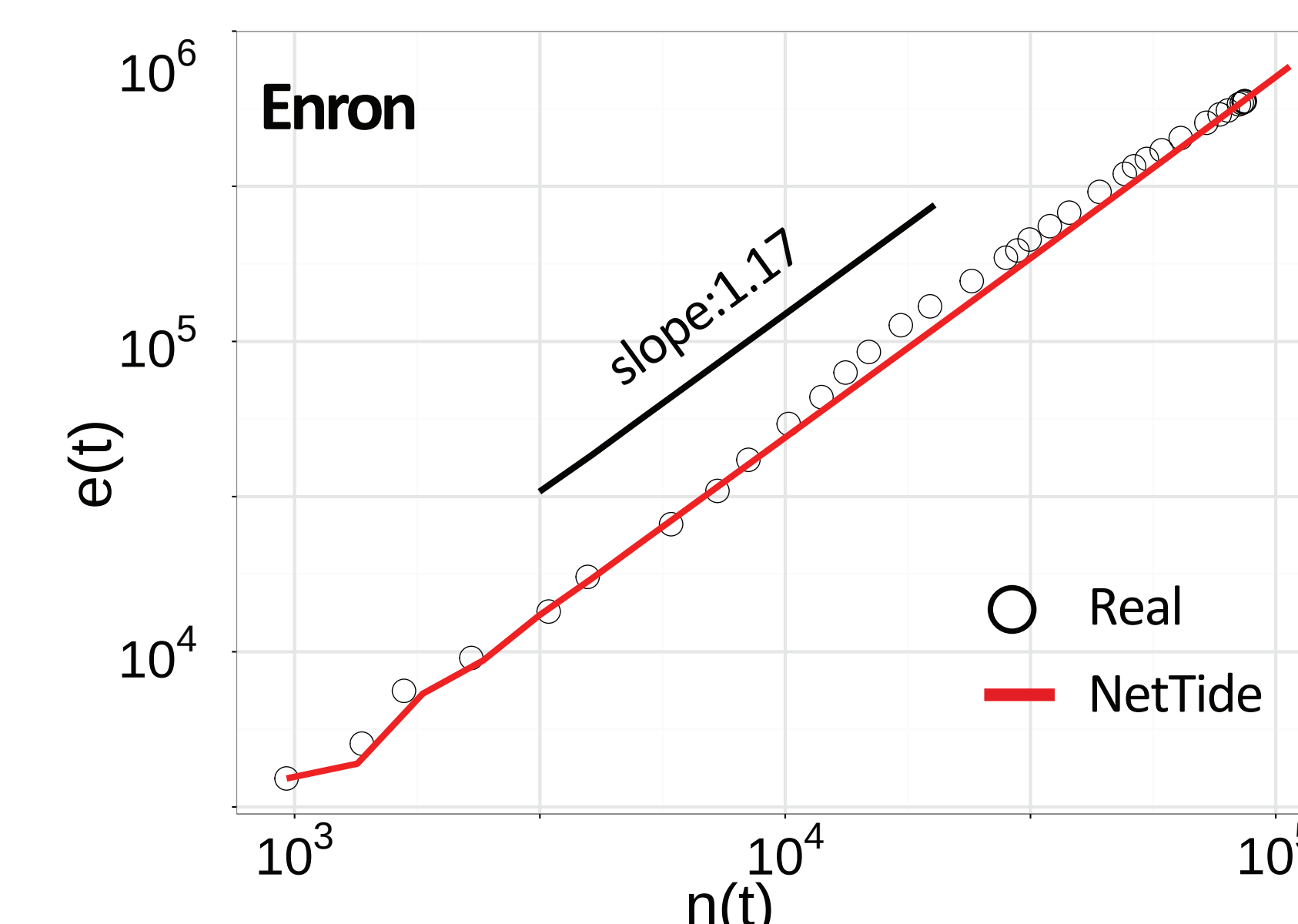
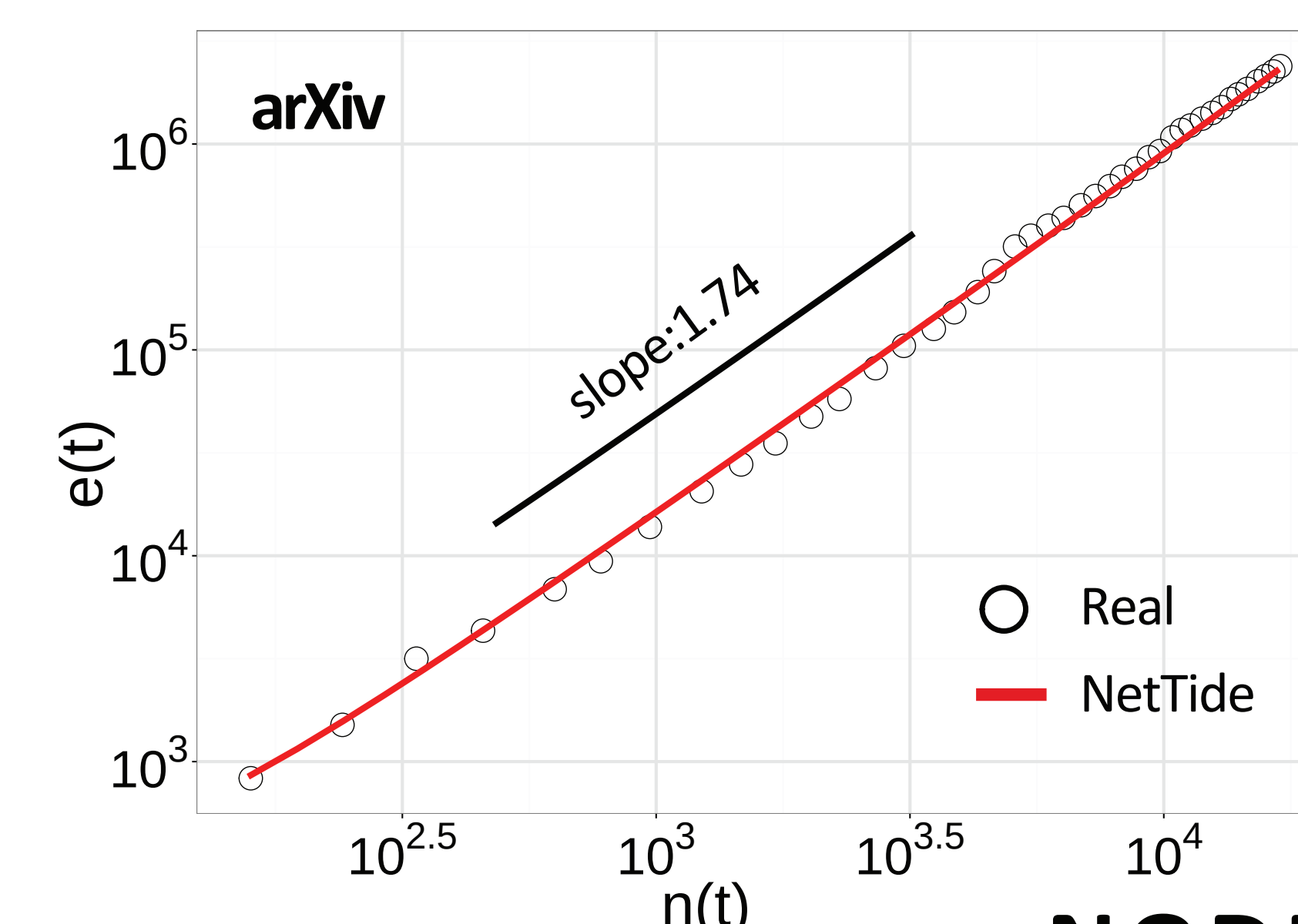
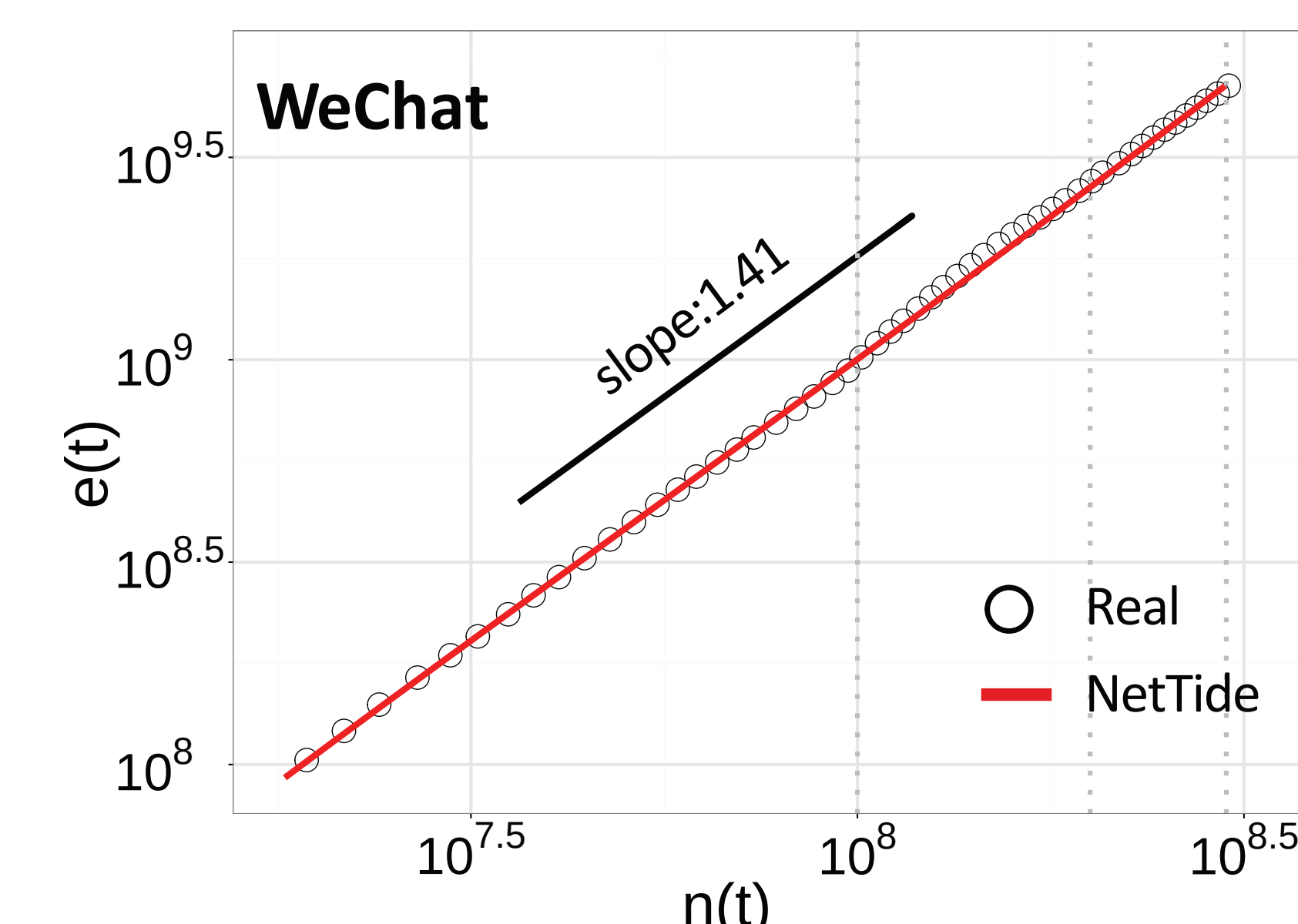
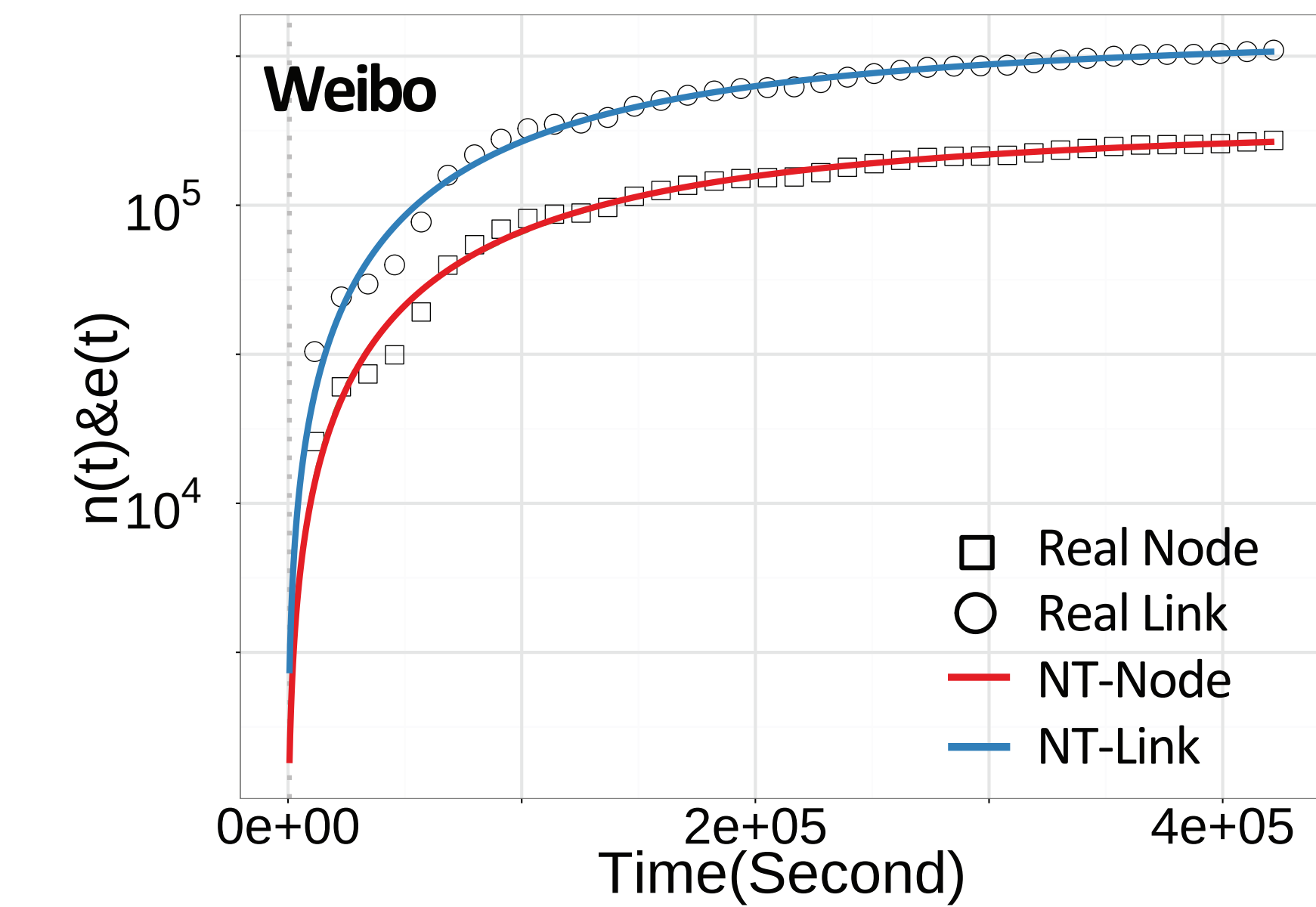
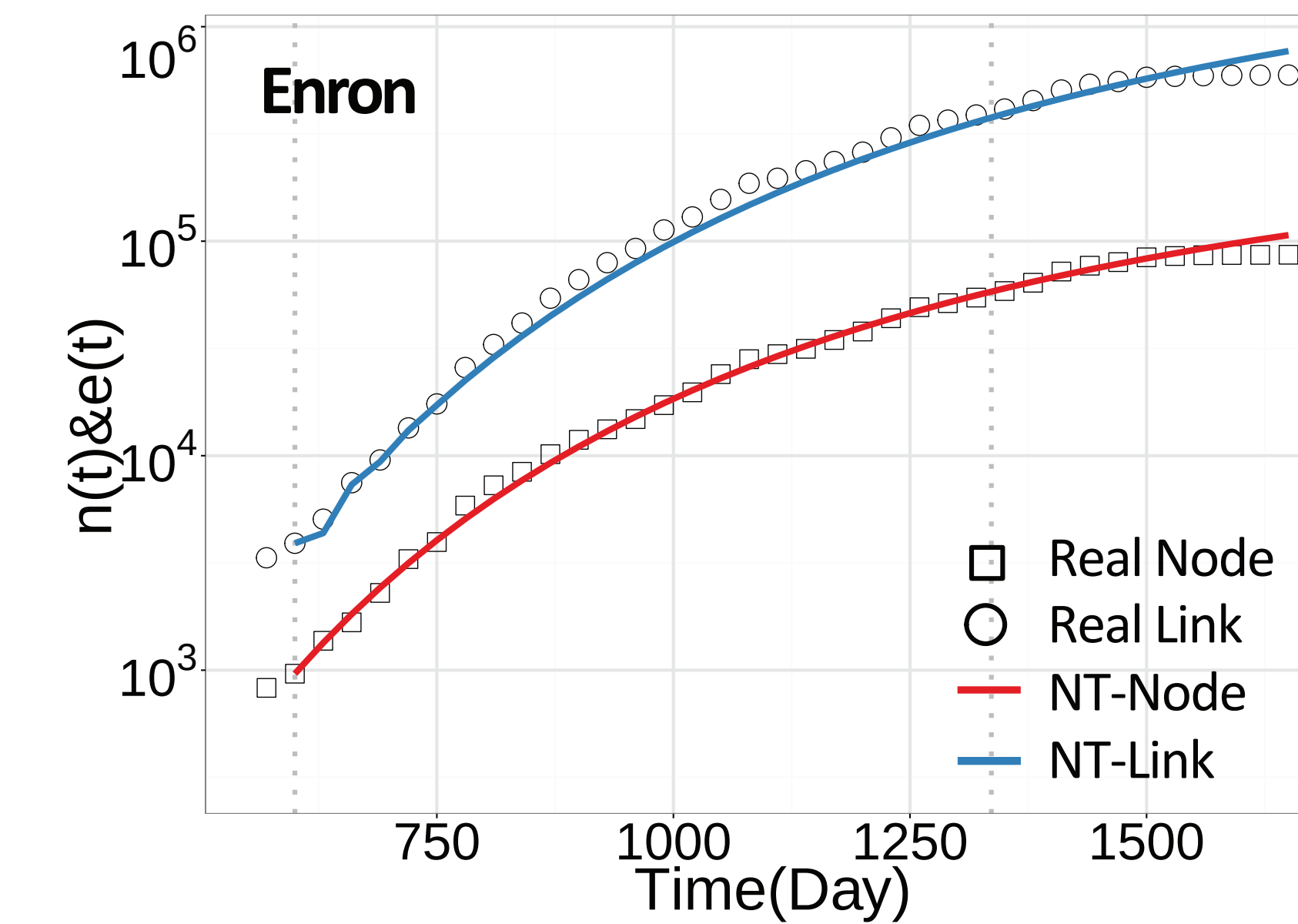
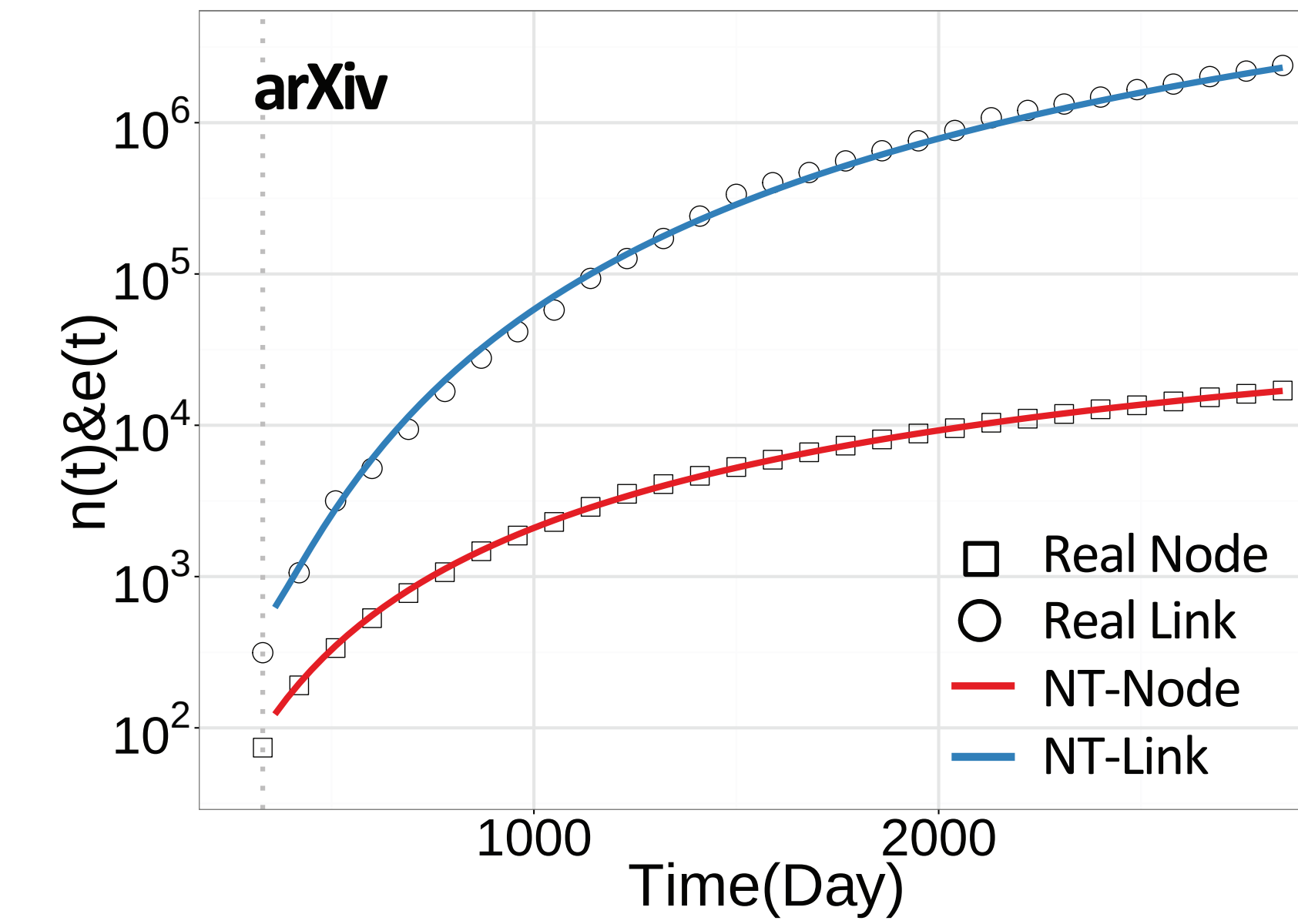
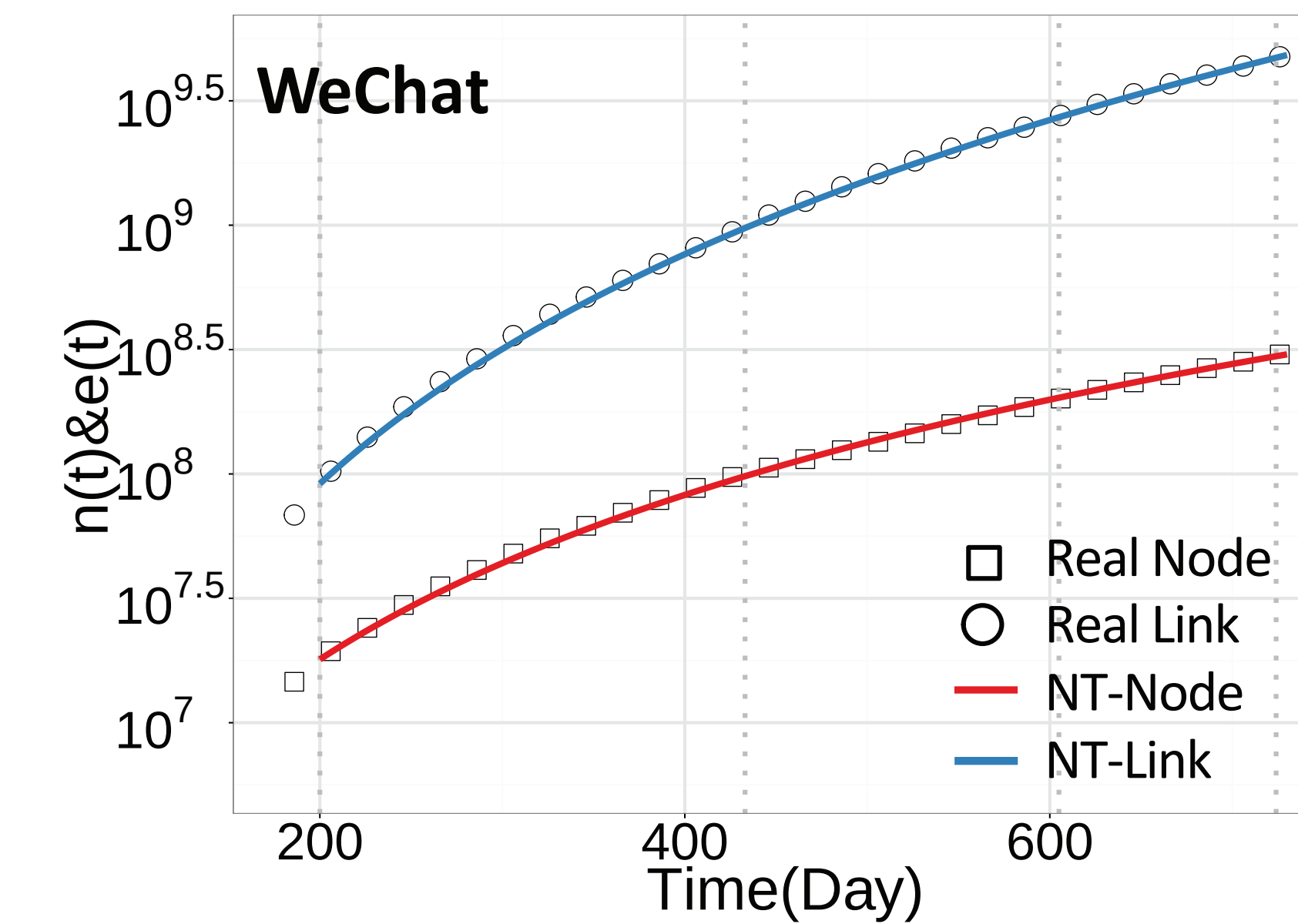


Reality disobeys sigmoids

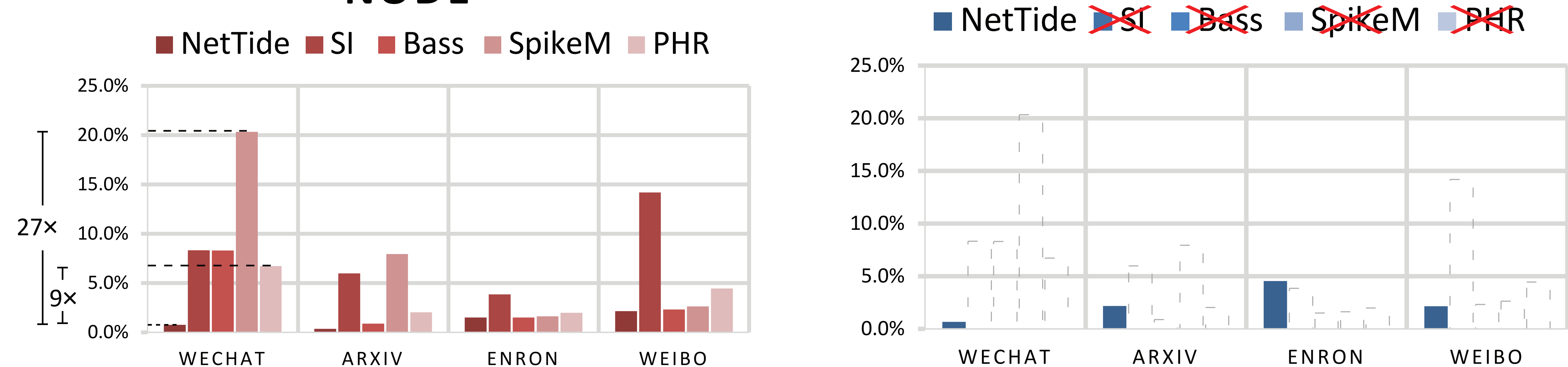
Experiments-Model Accuracy

NetTide fits reality.

Four datasets: WeChat, arXiv, Enron, Weibo. Three checkpoints: $n(t)$, $e(t)$, $e(n(t))$



NetTide outperforms baselines.



The NetTide Model

NetTide-Node:

$$\frac{dn(t)}{dt} = \frac{\beta}{t^\theta} n(t) (N - n(t))$$

θ : temporal fizzling exponent.

$$\text{Define: } Sigmoid(x) = N \frac{\lambda_0 e^x}{1 + \lambda_0 e^x} \quad \lambda_0 = \frac{n_0}{N - n_0}$$

• $\theta=1$, Log-Logistic growth

$$n(t) = Sigmoid\left(\ln\left(\frac{t}{t_0}\right)^{\beta N}\right) \quad n(t) = n_0 \left(\frac{t}{t_0}\right)^{\beta N} \quad \text{When } n(t) \ll N$$

• $\theta \neq 1$, Fizzle-Logistic growth

$$n(t) = Sigmoid\left(\frac{\beta N}{1-\theta} (t^{1-\theta} - t_0^{1-\theta})\right) \quad n(t) = n_0 \exp\left(\frac{\beta N}{1-\theta} (t^{1-\theta} - t_0^{1-\theta})\right) \quad \text{When } n(t) \ll N$$

• $\theta=0$, Sigmoid/Logistic growth

like SI, Bass

NetTide-Link:

$$\frac{de(t)}{dt} = \frac{\beta'}{t^\theta} n(t) \left(\alpha(n(t) - 1)^\gamma - \frac{e(t)}{n(t)} \right) + 2 \frac{dn(t)}{dt}$$

• Micro process

Internal and external links

• Underlying organization structure

Modeled by Kronecker graph

Densification: $Y = \ln(E) / \ln(N)$

Experiments-Model forecasting

NetTide forecasts future well.

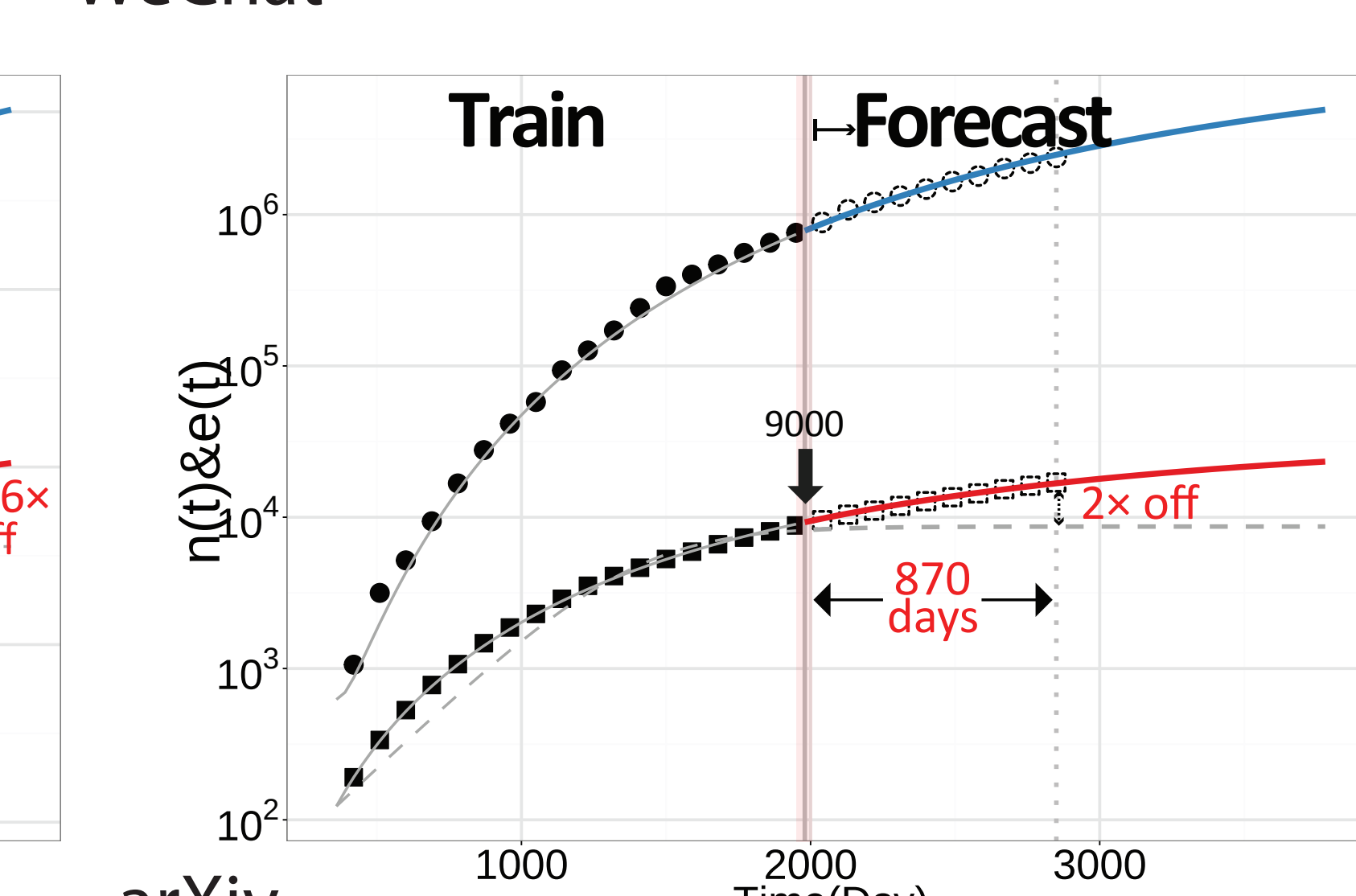
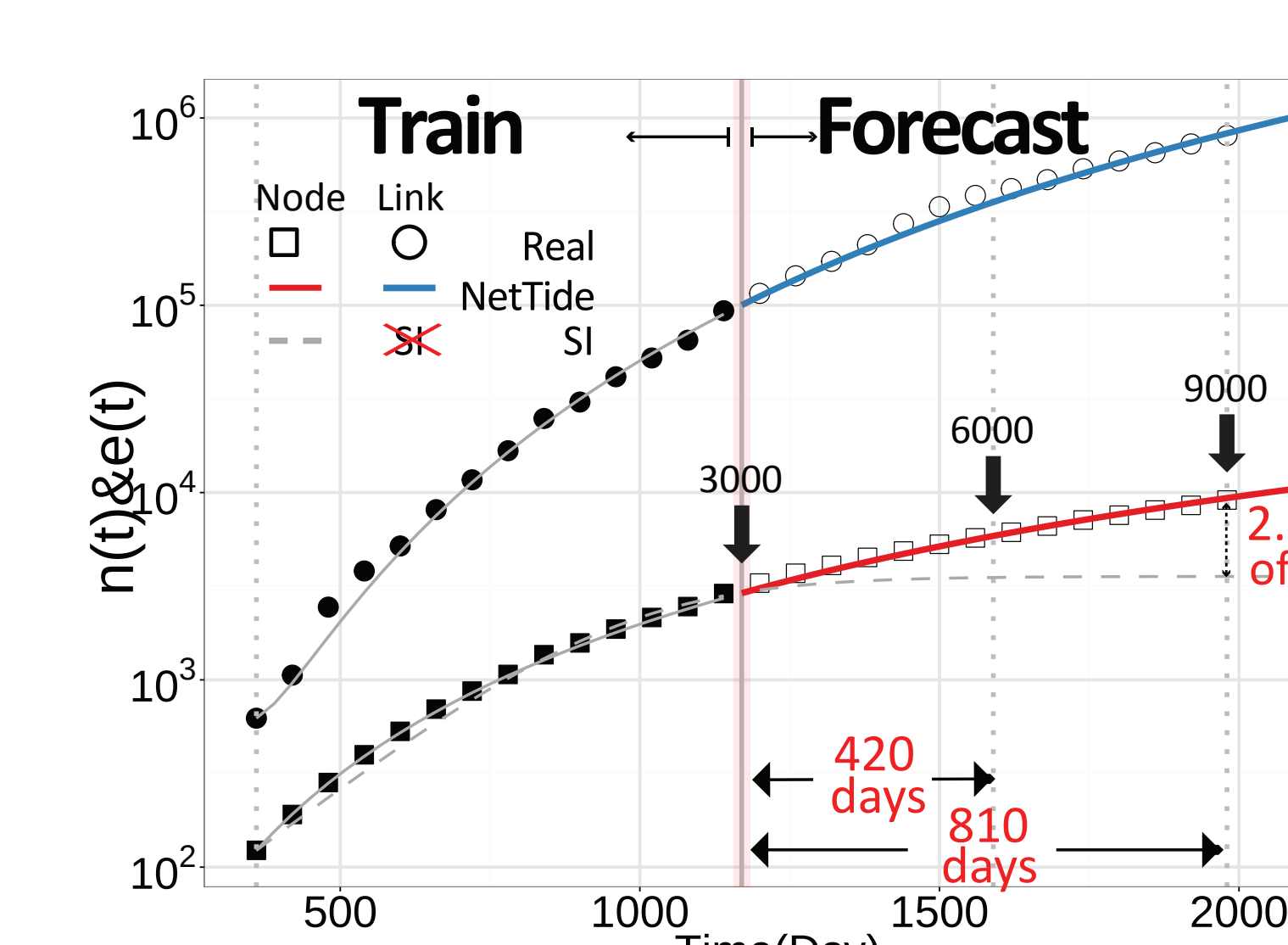
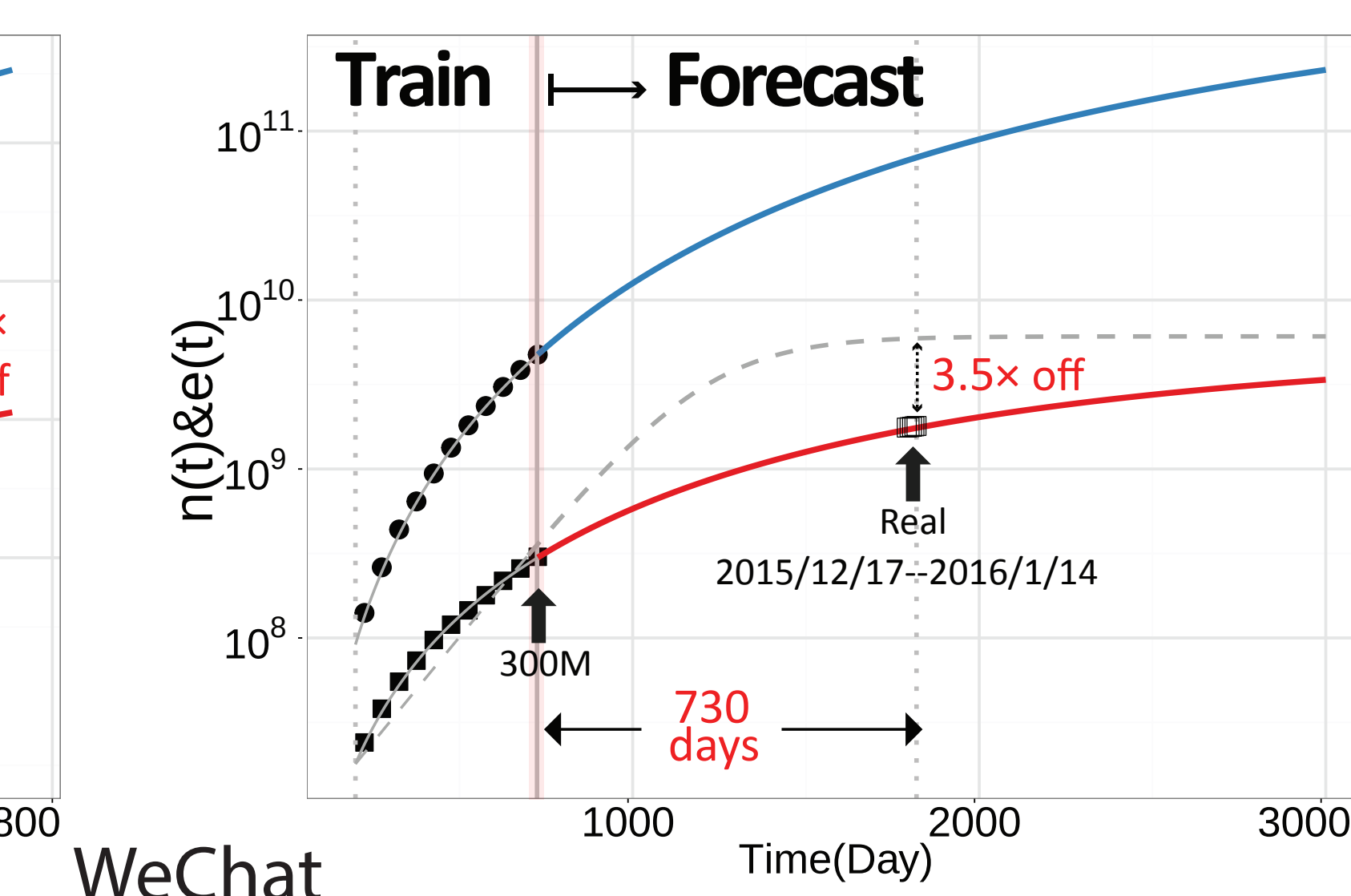
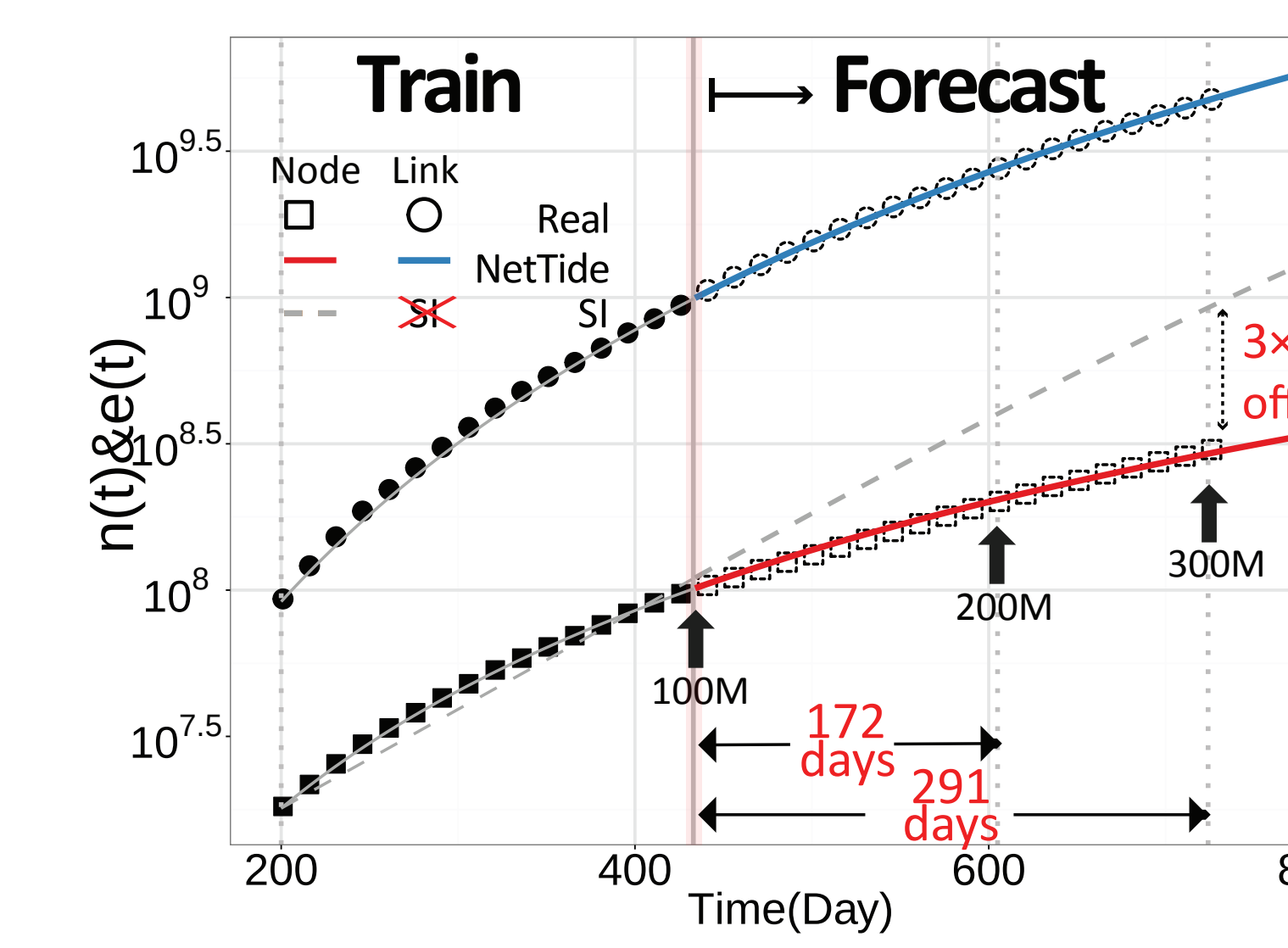
730 days into the future,
3% error for the WeChat Case.

• Short-term forecasting

• Overall forecasting

• Milestone forecasting

• Long-term forecasting, 2 years ahead



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