

# Partition-tolerant Blockchain Protocol for Microgrid Systems

Shoma Mori

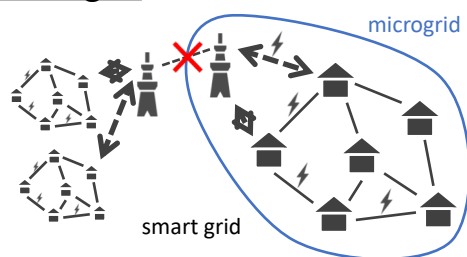
School of Computing, Tokyo Institute of Technology

2020.9.30 @第16回情報科学ワークショップ

2/9

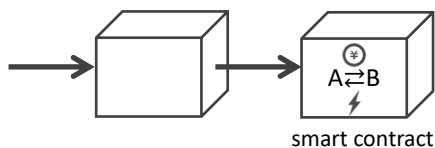
## Background

Microgrid [Lasseter *et al.* (PESC, 2004)]



- A geographically limited group
- Compensates for electricity within the community
- Resistant to partition (e.g. disasters)

Blockchain

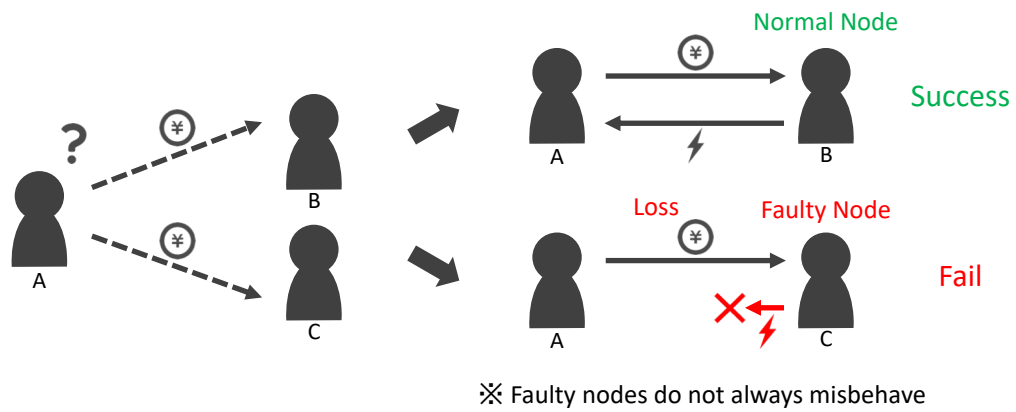


- Distributed, transparent, secure log
- Permissioned blockchain is compatible with the microgrid

➡ **Blockchain-based Microgrid**  
[Mengelkamp *et al.* (Appl. Energy, 2017)]

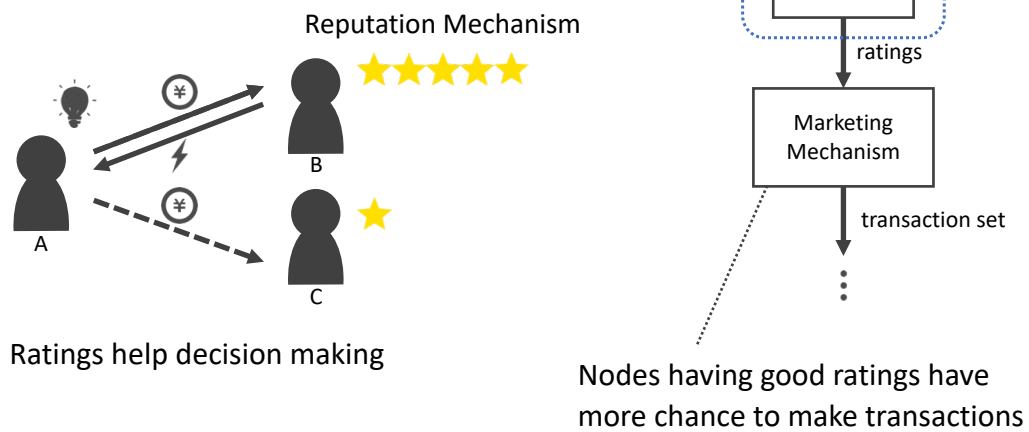
# Problem

## Energy Market



# Proposal

## Reputation System



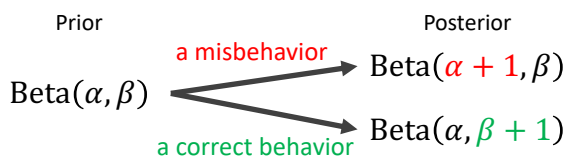
## Related Work

### The Beta Reputation System [Josang *et al.* (Bled eConference, 2002)]

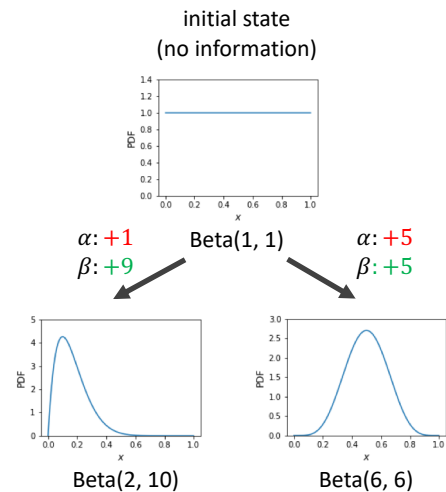
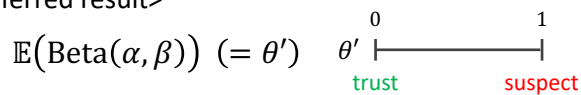
Node  $i$  thinks node  $j$  misbehaves with probability  $\theta$

$$\begin{cases} \theta = 0 \Rightarrow \text{normal node} \\ \theta > 0 \Rightarrow \text{faulty node} \end{cases}$$

<Bayesian inference>

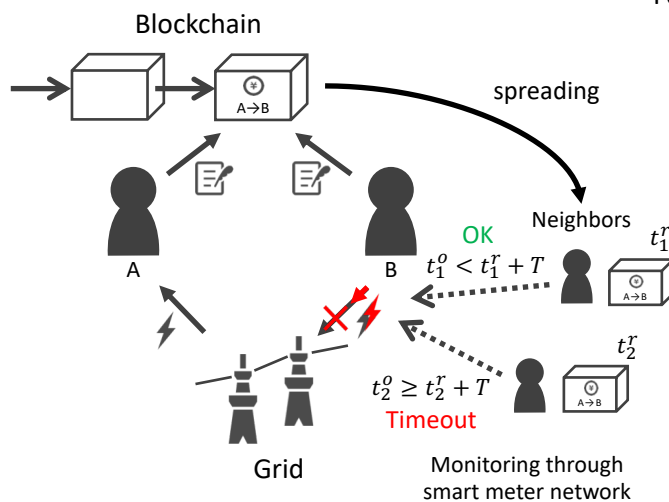


<Inferred result>



## Observation

### Transaction Flow



For a neighbor node  $i$ ,

$t_i^r$ : receiving time of the block

$t_i^o$ : observation time of the electricity transmission

$$\begin{cases} t_i^o < t_i^r + T \Rightarrow \text{correct behavior} \\ t_i^o \geq t_i^r + T \Rightarrow \text{misbehavior} \end{cases}$$

Observations & inferences are not perfect

$\Rightarrow$  Infer as **accurate & fast** as possible

$$\begin{cases} \theta' \ll \theta \Rightarrow \text{risk to encounter with misbehaviors} \\ \theta' \gg \theta \Rightarrow \text{risk to miss correct behaviors} \end{cases}$$

# Reputation Mechanism

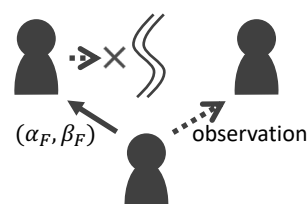
## Better ways of updating $\alpha$ and $\beta$

- Standard

$$\alpha := \alpha + v, \beta := \beta + (1 - v) \quad \begin{cases} v = 0, & \text{correct behavior} \\ v = 1, & \text{misbehavior} \end{cases}$$

- Combine feedback from other nodes  $(\alpha_F, \beta_F)$

$$\begin{pmatrix} \alpha \\ \beta \end{pmatrix} := \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + b \begin{pmatrix} \alpha_F \\ \beta_F \end{pmatrix} \quad (b: \text{const})$$



# Reputation Mechanism (cont.)

- Decay factor  $u$

$$\alpha := u\alpha + v, \beta := u\beta + (1 - v)$$

- ✓ Gradually forget the past experience
- ✓ Put priority on recent behaviors
- ✓ Even in the absence of observations,  $\alpha := u\alpha, \beta := u\beta$

- Feedback weight  $w$  (e.g. according to amount of electricity)

$$\alpha := \alpha + wv, \beta := \beta + w(1 - v)$$

## Summary & Future Work

- Blockchain-based Microgrid
- Beta reputation system for helping decision making
  - Feedback from others
  - Decay factor
  - Feedback weight

### Future Work

- More analysis on detailed attacker models
- Measurements of the reputation system by implementation