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Autonomous fault-diagnosis and decision making algorithm for determining faulty nodes in distributed wireless networks

Key words: Fault-diagnosis, Decision making, Byzantine agreement, Distributed wireless net-works, Consensus

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Motivation/Main ideas

Motivation

- Provide a distributed method in order to identify Byzantine members in a network. The proposed algorithm reaches Fault Diagnosis Agreement (FDA) in each network member.

Main ideas

- Each healthy unit detects a local list of malicious units that results in lower packet transmissions in the network
- Our proposed algorithm solves FDA problems in $2t+1$ rounds of packet transmissions, and the bit complexity in each wireless node is $O(n^{t+1})$.

FDA

The proposed Algorithm consists of two main phases:

- Byzantine Agreement (BA) phase.
- Fault Diagnosis Agreement (FDA) phase.

Basic fault identification concepts

- The following equation provides the main fault identification method:

$$\text{if} \quad \mathrm{val}(P_j P_i) \neq \mathrm{val}(P_j P_v P_i) \quad \text{then}$$
$$\mathrm{FU}(P_j) \vee \mathrm{FU}(P_v)$$

BA Phase

- This phase consists of two parallel subphases; message exchange phase and local fault-diagnosis phase.

The message exchange phase starts when the source processor transmits its initial value to all other processors, and since then the message exchange process is used to build a (t+1)-level EG-tree in each fault-free processor.

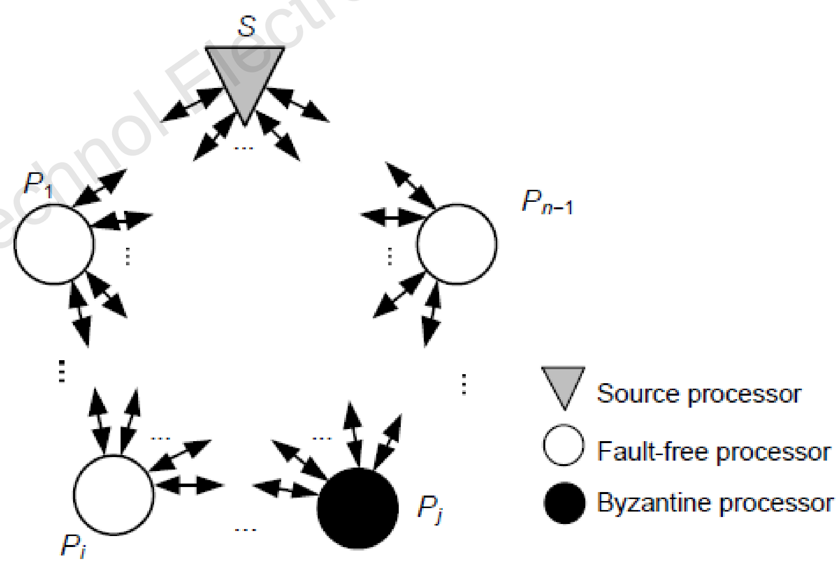

Fig. 1 A fully connected network with n processors and $\lfloor (n-1)/3 \rfloor$ faulty processors

BA Phase

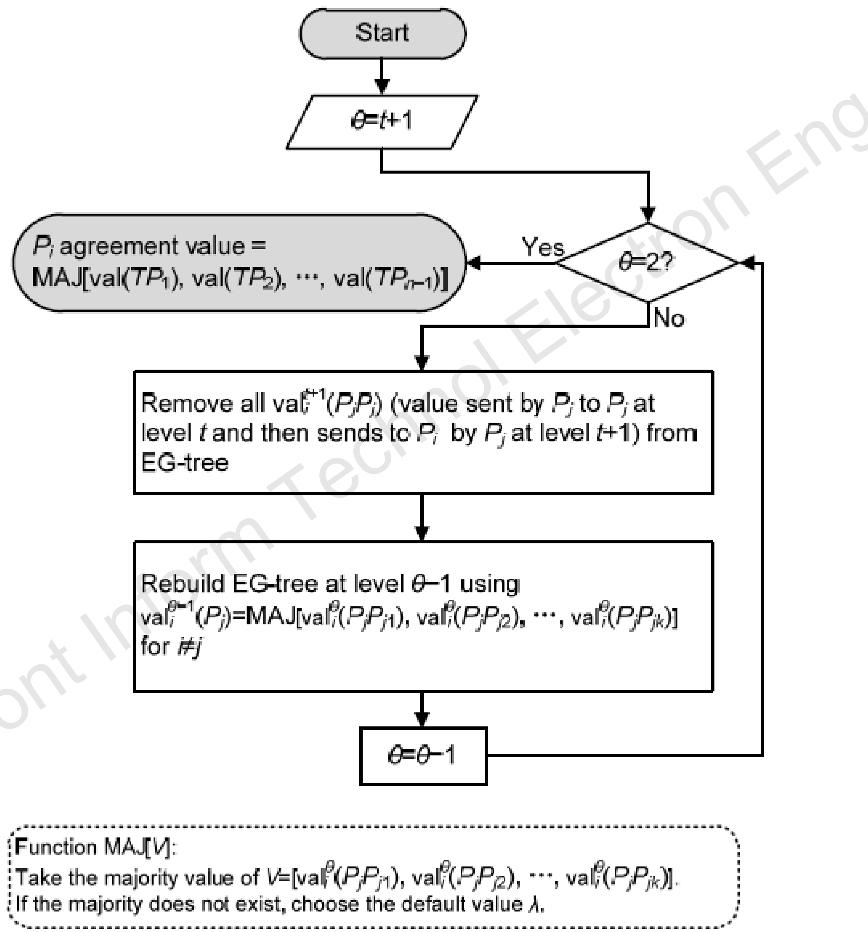

Fig. 4 Finding the Byzantine agreement value in fault-free processor P_i (T=source processor and MAJ is the majority function)

FDA Phase

- To obtain a same set of faulty units for all fault-free processors, the processors are moved to the FDA phase.

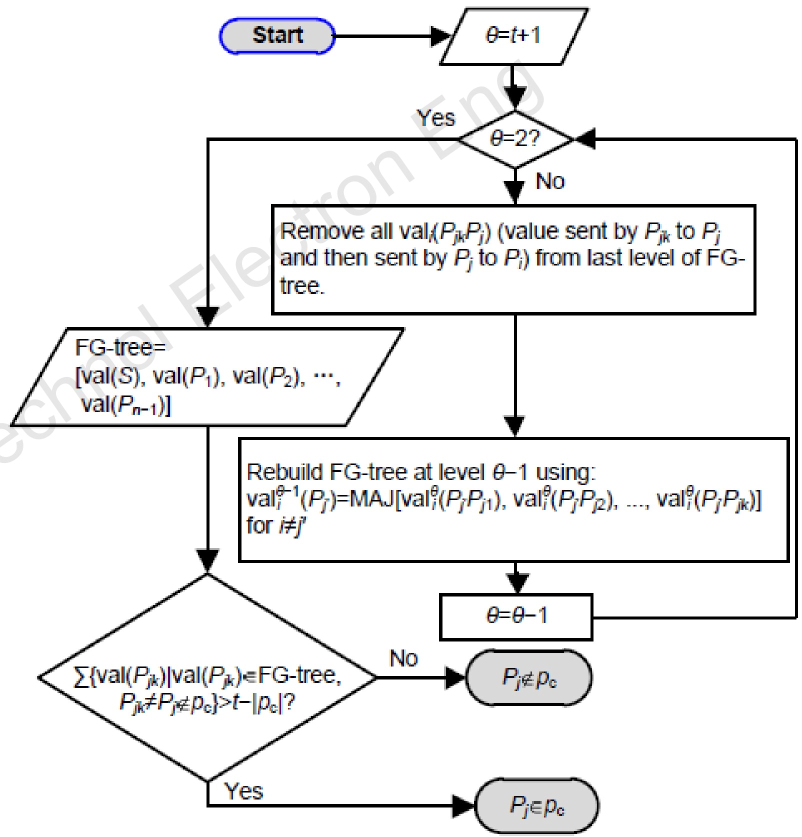

Fig. 6 Flowchart of the subphase of global detection of faulty units in processor P_i to check the status of P_j

Major results

Table 1 Comparison of FDA algorithms

Algorithm	Local fault diagnosis	Bit complexity	Number of rounds	Consensus	
				BA	FDA
Hsiao *et al.* (2000)	–	$O(n^{2t+1})$	$(n+1)(t+1)$	√	√
Ayeb and Farhat (2004)	√	$O(n^{t-\rho})$	$t+1-\rho$	√	–
Chiang *et al.* (2009)	√	$O(n)$	3	–	–
Our method	√	$O(n^{t+1})$	$2t+1$	√	√

The algorithm in Ayeb and Farhat (2004) can stop message transmission based on the number of detected faulty units

Major results

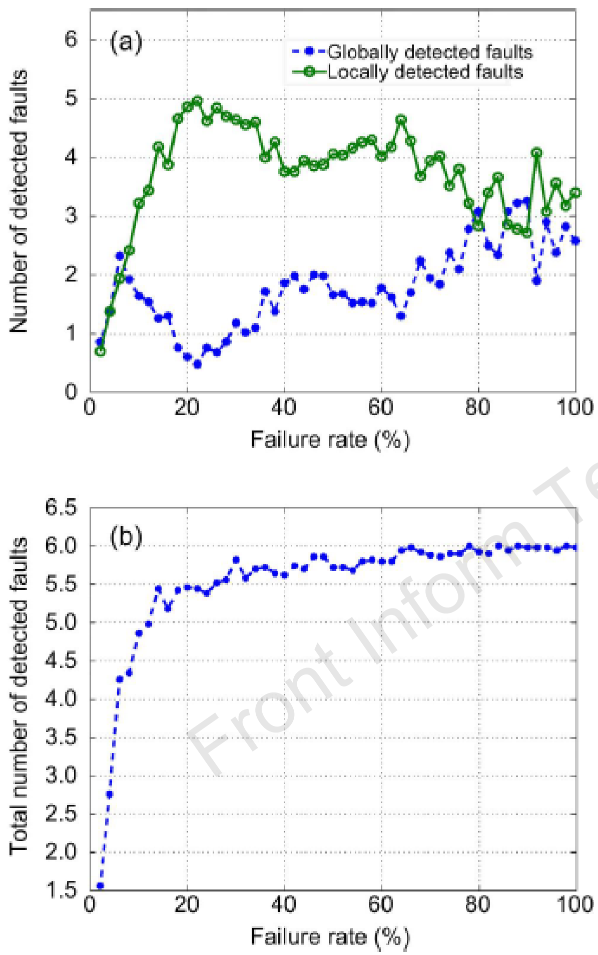

Fig. 12 Number of faults detected in processor P_1: (a) faults detected globally and locally; (b) total number of faults detected

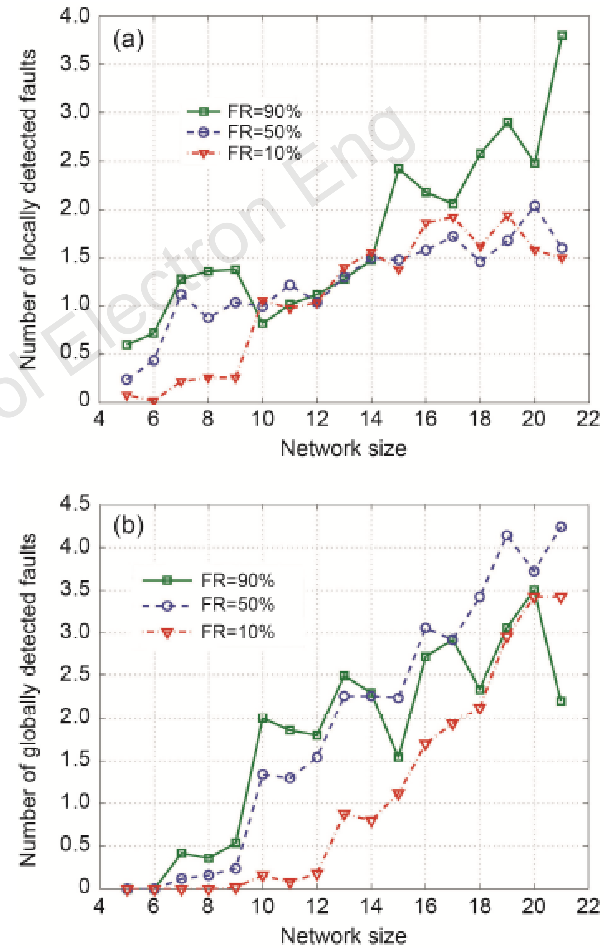

Fig. 13 Number of faults detected locally (a) and globally (b) in processor P_1 for different network sizes (FR: failure rate)

Conclusions

- In this work, we provide a solid solution for the fault-diagnosis problem using the framework of Byzantine general problem.
  - The proposed solution is compared with prominent Byzantine agreement (BA) algorithms in terms of the number of required message transmissions and packet size complexity.
  - The proposed solution simplifies the solution of fault diagnosis
  - agreement (FDA) and BA problems in complete graph networks.
- We provide a new evidence-based fault-diagnosis algorithm that benefits from contradictory transmissions of Byzantine members to reveal their faulty behavior.