Chapter 22
Fault Tolerance Model for Efficient Actor Recovery Paradigm in WSAN

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ABSTRACT

Wireless sensor and actor networks (WSAN) is an area where sensors and actors collaborate to sense, handle and perform tasks in real-time. Thus, reliability is an important factor. Due to the natural of WSAN, actor nodes are open to failure. Failure of actor nodes degrades the network performance and may lead to network disjoint. Thus, fault tolerance techniques should be applied to insure the efficiency of the network. In an earlier work, the authors proposed an efficient actor recovery paradigm (EAR) for WSAN which handles the critical actor node failure and recovery while maintaining QoS. EAR is supported with node monitoring and critical node detection (NMCND), network integration and message forwarding (NIMF), priority-based routing for node failure avoidance (PRNFA) and backup selection algorithms. In this article, the authors extend the work by adding a fault tolerance mathematical model. By evaluating the model, EAR shows to manage fault tolerance in deferent levels. To evaluate the effectiveness, the EAR fault tolerance is evaluated by simulation using OMNET++ Simulation. In addition, EAR reliability is measured and compared with RNF, DPCRA, ACR, and ACRA.

INTRODUCTION

Wireless Sensor and Actor Networks (WSAN) is a field where actors and sensors collaborate together in order to perform specific tasks or transmit and process information. A WSAN can be described as a distributed wireless network. A WSAN consists of sensors, actors, and a base station. The WSAN has many advantages over the regular WSN. One of the most efficient characteristics is the high energy and

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low power consumption. The actor network integrates with the sensor network to implement the Wireless Sensor and Actor Network (Akyildiz & Kasimoglu). Sensors are responsible for sensing specific actions or events and transmitting the sensed event to the actor node. On the other hand, Actors are high performance nodes that have the capability to collect, process, transmit data, and perform actions. Actor are resource-rich nodes equipped with high capabilities, wide transmission range, and strong computation power. Also, they run on high power source (Liu, Ren, Li, Chen, & Shen, 2012; Melodia, Pompili, & Akyildiz). Actors are responsible for collecting and processing the data which are sent by the sensors. In WSAN, an actor node can communicate with several sensors. Communication in the WSAN can be classified as sensor-actor communication, actor-actor communication, or actor-sink communication. WSAN can be automated or semi-automated. For the automated WSAN, the sensor sends the collected data to the actor node, and the actor node receives, processes and performs the action needed. For the semi-automated WSAN, sensors send data to the sink and the sink sends the data to the actor nodes (Lameski, Zdravevski, Kulakov, & Davcev, 2011). In WSAN, sensor nodes consist of limited storage, processing, and power capabilities while actor nodes are powerful nodes. Due to the architecture, the number of sensors can range up to thousands while the number of actor nodes is much lower (Vasanthi & Annadurai, 2006). WSAN can assist many real-time applications such as smart energy grids, battlefield surveillance, and cloud computing, as well as uses in medical, industrial, and nuclear fields. Significant parameters may affect the WSAN, including energy efficiency, transmission media, scalability, and environment. The selection of the parameters for optimization depends on the application. It is essential to ensure the communication and efficiency of WSAN. Thus, it is essential to maintain the fault tolerance of the WSAN.

Fault tolerance is the ability of a network to preserve its services regardless of the occurrence of faults. The general taxonomy of fault tolerance techniques consists of (Tanenbaum, S., & Steen, 2002):

- Fault prevention
- Fault detection
- Fault isolation
- Fault identification
- Fault recovery

Fault tolerant techniques can manage one or more types of fault in one or more network layer. There are variety of fault sources such as: nodes mobility, congestion, sensor nodes resource limitation, communication link failure, and actor node failure. The impact of failure can be identified in correspondence to the failure cause and the overall impact over the network. A failure of an actor may cause losing communication between nodes. In fact, a failure of a critical actor had higher impact on the network since it can lead to a network disjoint. Critical actor is an actor in which its failure causes network partitioning. In case of critical actor failure, restoration process should take place. Failure actor restoration may be take place by replacing it with a redundant backup actor or by an adjacent neighbor.

The actor nodes may include high performance features which can increase the power and enhance the usage of the network in general. Maintaining the inter-actor connectivity is essential in WSAN. Thus, we intend to focus on fault tolerance in reference to critical actor node failure. In our earlier study (Mahjoub & Elleithy, 2017) we introduced an efficient actor recovery paradigms (EAR) for WSAN. Despite to earlier models, EAR handle actor node failure and recovery while maintaining quality of service (QoS). In this paper, we're proposing a fault tolerance model plus extending the evaluation of fault