**Interprocess Communication in Distributed Wireless Sensor Network**

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*Abstract*—Wireless Sensor Network (WSN) has been deployed in a wide range of mission critical task from bushfire detection to water quality monitoring. Such system can be abstracted by representing each sensor with one process in computer system. This report proposed an algorithm that utilize inter-process communication mechanism to simulate such communication pattern. The experiment shows how communication can be minimized and how encryption algorithm can be parallelized in purposed algorithm.

Keywords-component; Inter-process Communication, openmp, Message Passing Interface, Wireless Sensor Network

# Introduction

Inter-process Communication (IPC) defines a set of mechanism that support data sharing and communication among[1]. It is commonly used in wireless sensor network (WSN) as communication management method.

This report aims to explore different Inter-Process Communication approaches to simulate the communication pattern and discover most efficient communication structure. The algorithm outcomes will provide considerably lower communication cost for large scale network.

Target network is assumed to be a 2-dimensional cartesian grid, where each coordinate represents a sensor (process). An extra process is introduced to simulate base station in network. The simulation consists of multiple iteration, and for each iteration each sensor sends an encrypted message of random number to its neighbor. An encrypted event is to be reported to base station if the sensor receives at least 3 identical numbers from its neighbor.

There are three objectives being identified in this scenario. (1) Minimize the frequency of message passing between sensor and base station. (2) Minimize the communication among sensors. (3) Speedup the encryption of message with parallelization.

# Design Scheme for IPC

## IPC methods

Message Passing Interface (MPI) is a library specification for message-passing in distributed system [2], which is also one of the most used message passing standard in both industry and academy [3]. MPI provides rich features of both point-to-point and collective communication. Compare to other standards, MPI provides several advantages. (1) MPI provides more portable libraries compare to older message passing standards [4]. (2) MPI is capable of delivering high performance on HPC system, and it is optimized on the hardware [4][5]. The implementation of MPI standard is vendor specific. One of the most used open source implementations is OpenMPI [6]. Therefore, I have chosen OpenMPI to implement sensor-sensor and sensor-base communication.

OpenMP stands for Open Multi-Processing. It is an application programming interface that support shared memory parallelization. Its behaviors are defined by a set compiler directives and runtime environment variables [7]. OpenMP follows fork-join model whereas at the start of program, there is only one master thread. A set of slave threads can be dynamically forked, and workload is distributed across slave processes. In the case of WSN, OpenMP is deployed to speedup encryption and decryption process.

## Algorithm

To incorporate the fact that sensor network perfectly fit into a 2-dimensional cartesian grid. MPI cartesian topology is constructed by excluding the rank of base station from MPI\_COMM\_GROUP, whereas the local communicator among sensors can be created from it.

Next step is generating random number. Random seed is feed as the addition of current timestamp and rank number, which keep our simulation close to real world. Due to the fact that we only have very limited amount of resources, high probability of event occurring is necessary to generate meaningful outcomes of simulation, which is achieved by taking first few bits of random number, which limit the number in range .

The criteria to trigger an event can only be interpreted as all-to-all message passing among nearest neighbors. MPI has its own build-in function for nearest neighbor collective communication. Its performance has been evaluated by some publications. In particular, Torsten and Jesper suggested that the scheduled sparse all-to-all can outperform naïve all-to-all operation by using blocking sendrecv[8]. It has been shown that 10% speedup can be observed by applying scheduled all-to-all operation, which reduce communication contention on cartesian mesh grid and utilize bidirectional communication link [8]. The application of such operation is limited to case where global knowledge of problem is known, otherwise deadlock could be generated. In the case of WSN, scheduled all-to-all operation is the more optimized build-in operation.

After local message passing stage, each node will need to iterate over all possible event values to determine if an event is triggered. If event is activated, the node will report such event to base station by blocking send. Besides random number generated, other event related information is also reported along, such as iteration number, timestamp and encryption/decryption time. As soon as simulation is completed, each sensor will send it's a summary which includes its basic information to base station. This message signals the completion of simulation.

At base station side, at the start of simulation, assume there are N-1 sensors. Base station will immediately spawn MPI\_Irecv along with an array *(RequestArray[0:2N])* filled with corresponding request. The first half of the array (event buffer) is used for receiving event message, the second half of the array (request array) is used for receiving the message that contains the completion signal of each nodes. The position in request array corresponds to the rank of base station is filled with MPI\_REQUEST\_NULL as null handler. During the simuation, if any request in region *RequestArray[0:N]* is received, the message is decrypted and stored as event, then the same request and MPI\_Irecv will be respawned. If any request in region *RequestArray[N:2N]* is received, it indicates the completion of corresponding rank. Both events receive request and completion signal receive request will be set to MPI\_REQUEST\_NULL. Those two types of message are distinguished by using different tags.

# encryption

## Encryption Algorithm

Advanced Encryption Standard (AES) is one of the most widely adopted symmetric encryption algorithms, which offer great security with litter computational resource required [9]. In order to parallelize both encryption and decryption operation, AES in counter mode is chosen as the encryption algorithm.

In realistic, the keys need to be distributed for security. IV need to be randomly generated in order to preserve the security of message. In the experiment, a few assumptions are made for simplicity, I assume that all the parties involved in communication share the same key and the same initialization vector (IV). The implementation of algorithm is taken from WjCryptLib [10]. This implementation offers build-in OpenMP implementation for both encryption and decryption.

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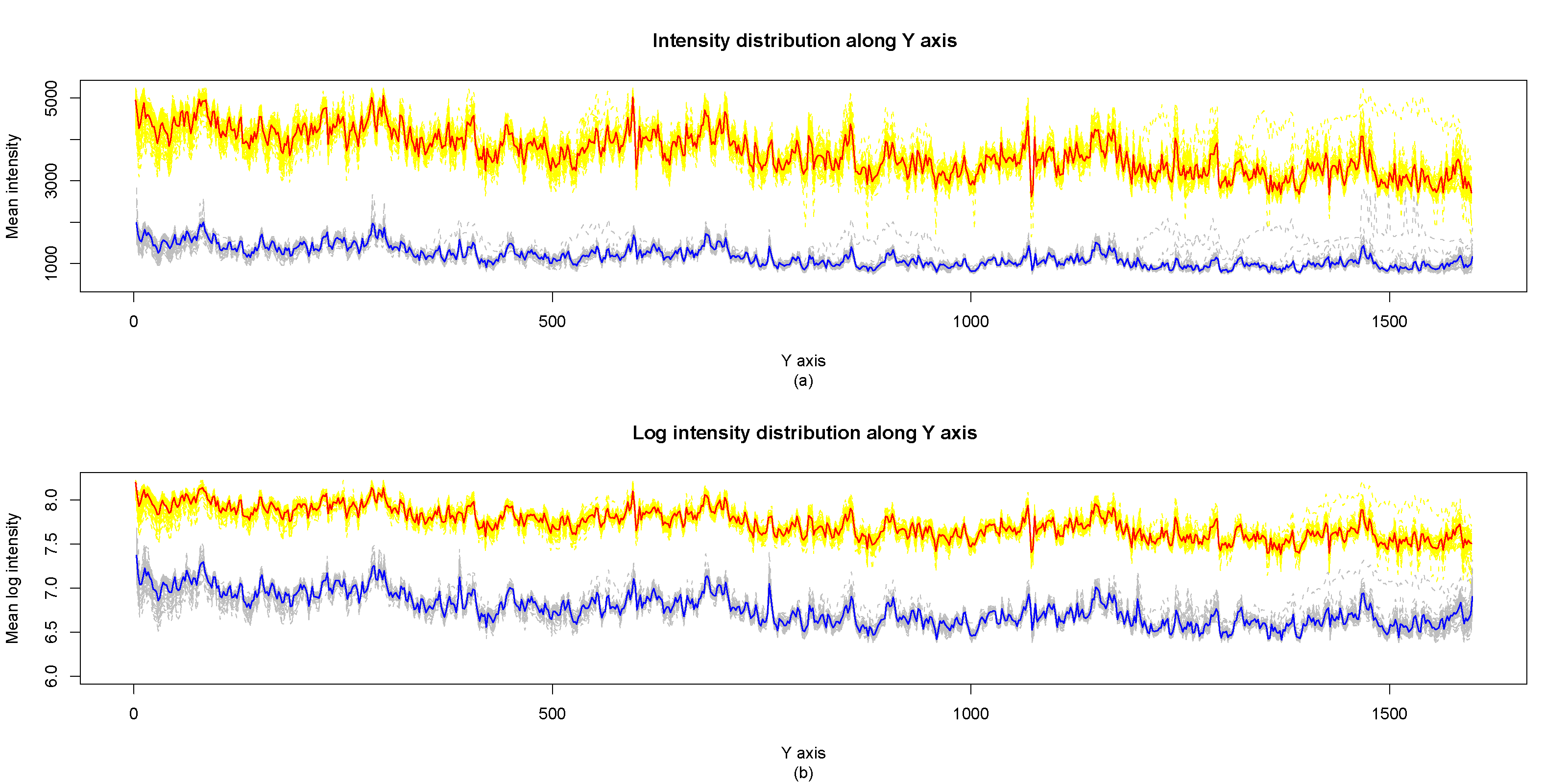
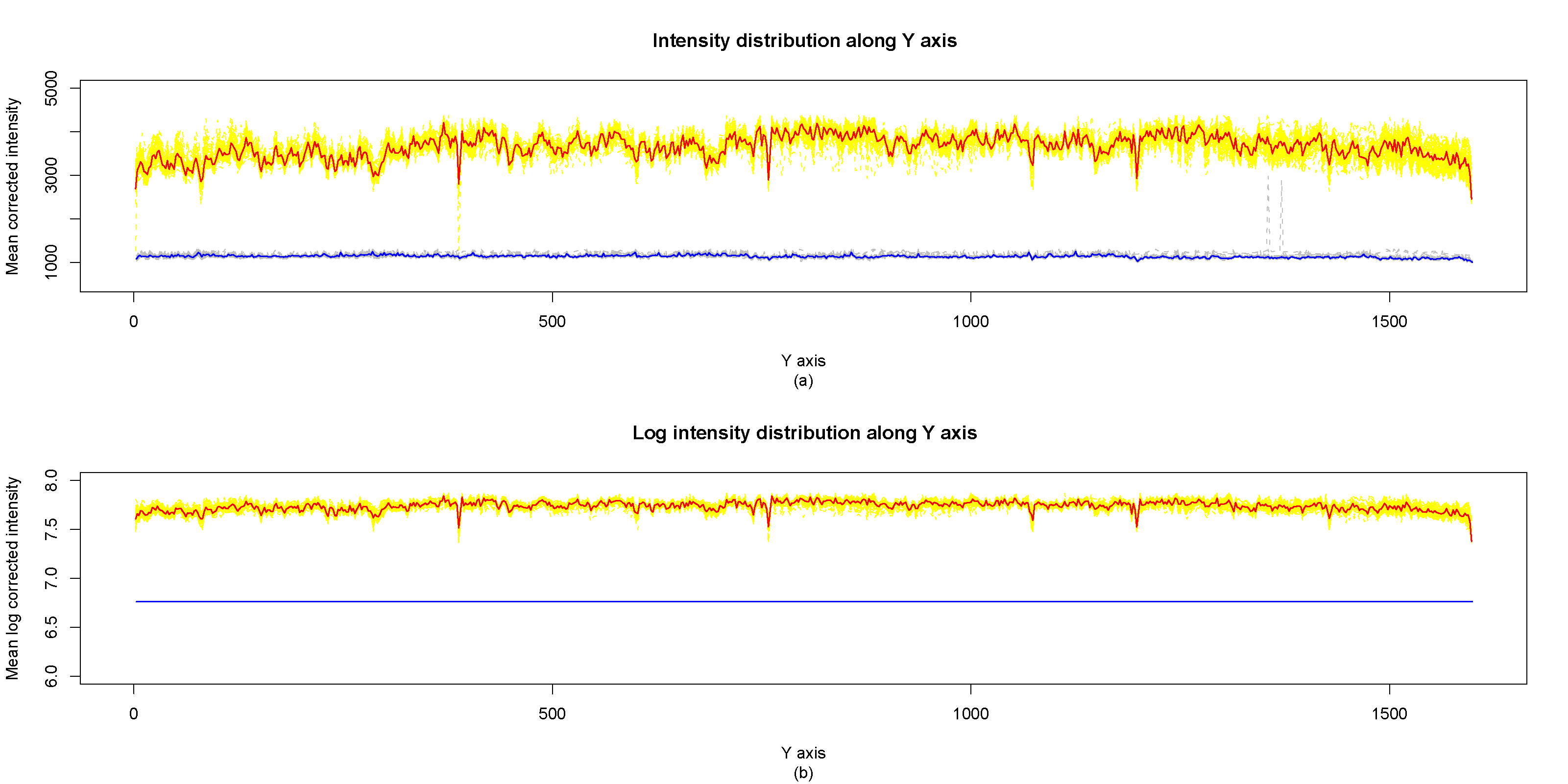
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8. Electronic Publication: Digital Object Identifiers (DOIs):

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Article in a conference proceedings:

1. H. Goto, Y. Hasegawa, and M. Tanaka, “Efficient Scheduling Focusing on the Duality of MPL Representatives,” Proc. IEEE Symp. Computational Intelligence in Scheduling (SCIS 07), IEEE Press, Dec. 2007, pp. 57-64, doi:10.1109/SCIS.2007.357670.

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