# Poster:Coordinationless Coordinated Fastlane Network Service in Wireless Sensor Networks


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## Abstract

Motivated by the observation that there is an increasingly aggravated conflict between the expanding sensor capabilities for sensing service/content and the limited network performance in wireless sensor networks (usually caused by cost, congestion, packet loss, resource limit, etc.), we provide a bottom-up approach to speedup the network by leveraging a group of nodes' (fog nodes) capacity and piling them up as a considerable amount for fastlane service. Based on theoretical analysis, it's shown that our approach could achieve global optimal request/resource allocation in a distributed manner and maximize the network service ability. The extensive experimental study conducted in various scenarios (TCP, UDP, and both, etc.) also shows that the proposed approach could adapt to different networking environments and achieve significant improvement of quality of service (QoS) and experience (QoE). Furthermore, our approach is shown to be able to achieve linear speedup as the number of fog nodes increases.


## 1 Introduction

Wireless sensor networks are widely used for environment monitoring in various applications. However, during the multi-hop transmission, it's hard to provide a stable guarantee on the reachability and stable connection between the sensors and the base station due to congestion, packet loss, resource limit, natural of wireless channels, etc. In traditional wireless sensor network transmission system designs, people proposed various methods to deal with these problems. For example, to solve the packet loss problem, most adopts retransmission [1], namely data packets with ACK receipt and retransmission. As a result, the base station may experience slow, jitter, nonfluent sensing data. Furthermore, since wireless traffic may vary in the network, it is difficult for the base station to predict its path connection status, which typically varies over time.

In such wireless sensor networks, depending on the sensor positions in the network, a sensor can observe distinct connection situations, due to the diverse congestion/packet-loss levels encountered along the paths of their respective connections to the base station. Aware of this, we exploit this diversity in connection to boost the performance of individual sensors. Specifically, a sensor can explore a group of other sensors (fog nodes) to the interested node (e.g., the base station), which may provide a cumulatively better connection.

This paper proposes a new method targeting fastlane network service in wireless sensor networks. Our contributions are : 1. Based on the recoverability of erasure codes, we provide a packet loss tolerance model and a corresponding coordinationless packet distribution method; 2. By using the idea of fog computing, we provide a group of sensors (fog nodes) for distributed reliable transmission. Specifically, the data sensed at each sensor is coded into multiple packets via erasure code. Each coded packet can be sent to anyone of the fog nodes, which is relayed to the base station. This is referred as "coordinationless" packet distribution. Each sensor and its fog nodes form multiple independent paths to the interest node (e.g., the base station). This is referred as "coordinated" connection path forming.

## 2 System Design

Consider a target sensor who intends to report a specific content of size $L$. The target sensor recode the content with erasure code from $m$ packets to $m+c$ packets. Once the interest node (e.g., the base station) receives any of $m$ coded packets, it can recover the content without any loss. Then the target sensor transmits the coded packets through multiple independent paths via the fog nodes to the interest node.

Specifically, the target sensor can seek help from other sensors by sending help requests to $n$ sensors. To respond to the request, each requested sensor probes its rate and feedbacks the rate to the target sensor. We assume that multiple requests can be sent out by the target sensor at the same time, and then processed by the requested fog nodes in parallel. Due to the fluctuation of network traffic and the effect of network protocols (e.g., TCP), it can take a certain amount of time (e.g., from tens of seconds to a minute) for the rate to reach a relatively stable value. After knowing the rates of $n$ requested users, the target user selects the $k$ users with the $k$ largest rates among the $n$ fog nodes to cooperate, where


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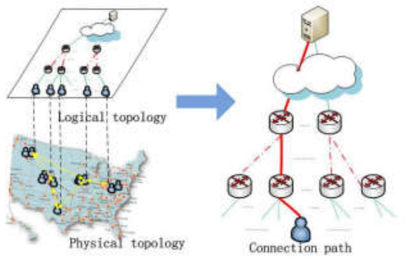


Figure 1. Logical Topology

$k = m + c$.

In this paper, we consider three kind of network topologies, physical topology, logical topology, and virtual topology. As shown in Fig.1, the physical topology provides hardware support for the logical topology, while the logical topology determines whether there could be a path between sensors and the service. When a sensor reports some content to the base station, there will form a logical path between the sensor and the service, as shown in the rightside of Fig.1.

# 3 Experimental Study

## 3.1 Experiment Settings

In the experiment implementation, we accumulate 50 sensors. The content/service we use is high definition video of encoded by H.264 standard.

In order to evaluate our system, we conduct a comparative study that employs two sensors at the same location (both physical and logical proximity) to watch the content at the same time, with one sensor using our system while the other not.

The measurement metrics we mainly focus on are related QoS and QoE, including throughput, network speedup, latency, jitter, packet loss, retransmissions, and server bandwidth usage/load. The number of fog nodes the sensor used is picked from $\{1, 2, 5, 10, 20\}$. The results of each kind of experiment setting is averaged over 10 runs.

## 3.2 Throughput and Speedup

Throughput is the rate of successful message delivery over a communication channel. We use the video transmission rate to evaluate the throughput by users using our system or not.

As shown in Fig.2(a), video transmission rate rapidly increases with the number of fog nodes increase in a linear relationship. It shows that our system speedup network connection and improve the quality of experience. Assuming the user and his friends network link speed are the same, the speed will increase $n$ times.

## 3.3 Latency and Packet Loss

We use sequence number to identify each packet, and a timer to check the time the packets have arrived. Due to congestion or improper routing problem, packet will experience delay and disorder at the time of arrival, which is often referred as jitter. Specifically, we count the percentage of the pause time in the experiment. As shown in Fig. 2(b), our video stream requires much more bandwidth than the bandwidth of any path. Without fog nodes' help, it would wait data almost all the time and continuously experiences jitters. However, when fog nodes are available, the total paused time shows a linear decreases as the growth of the number of fog nodes. This is because the overall bandwidth available for the sensor increases. Fig.3 illustrates that latency of packet delivery is 40% reduced with erasure coding based model than that of traditional model.

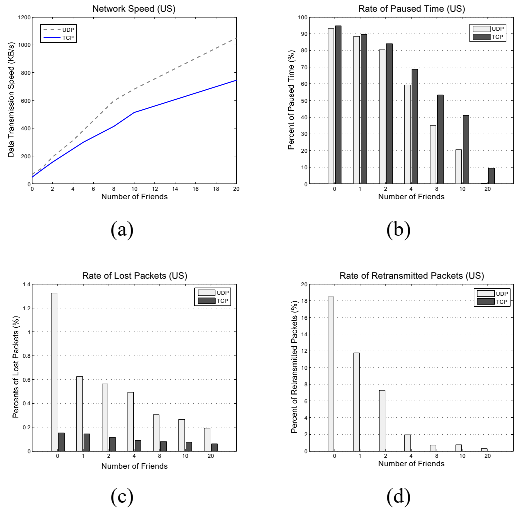


**Figure 2. (a)Relation between number of fog nodes and network speed (b)(c)(d)Experiment results of TCP/UDP implementation**

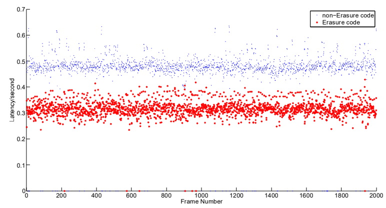


**Figure 3. Latency of Tansmission Model Based on Erasure Code and that of Tranditional Model**

Another reason caused jitter is packet loss. Note that we use erasure code to recode the video stream from $m$ packets to $m + c$ packets. Once the interest node (e.g., the base station) receives any of $m$ coded packets, it can recover the video stream without any loss. Since we transmit the coded packets through multiple independent paths, the earliest $m$ arrival of coded packets may help reduce the latency. According to the experiment, it may save about $1/3$ time compared with the sensor without the help of our proposed system. Furthermore, according to the nature of erasure code, the proposed system could suffer about 40% packet loss (when applying 3:5 erasure code).

# 4 References

[1] S. D. G. M. A. and K. I. V. et al. Multicastandunicastreal-timevideo streaming over wireless lans. *IEEE Trans. on Circuits and Systems for Video Tech.*, 12(6):524–534, November 2002.