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A QoS-based ONU Group Planning Algorithm for Smart Grid Communication Networks

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CONTENTS

I. INTRODUCTION

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- **A QoS based ONU group planning algorithm is for fiber-wireless hybrid networks.**
- **Fiber is used to carry smart grid two-way interactive business with Ethernet passive optical network (EPON) technology.**
- **On the user side, all kinds of sensors form a wireless sensor network (WSN).**

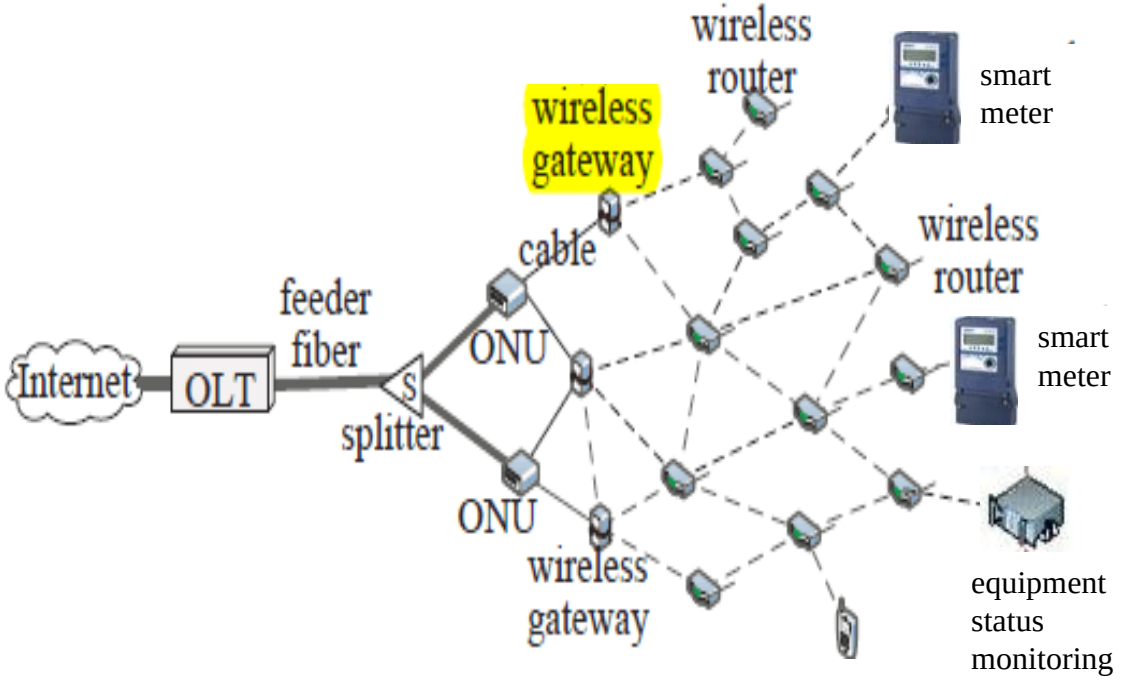
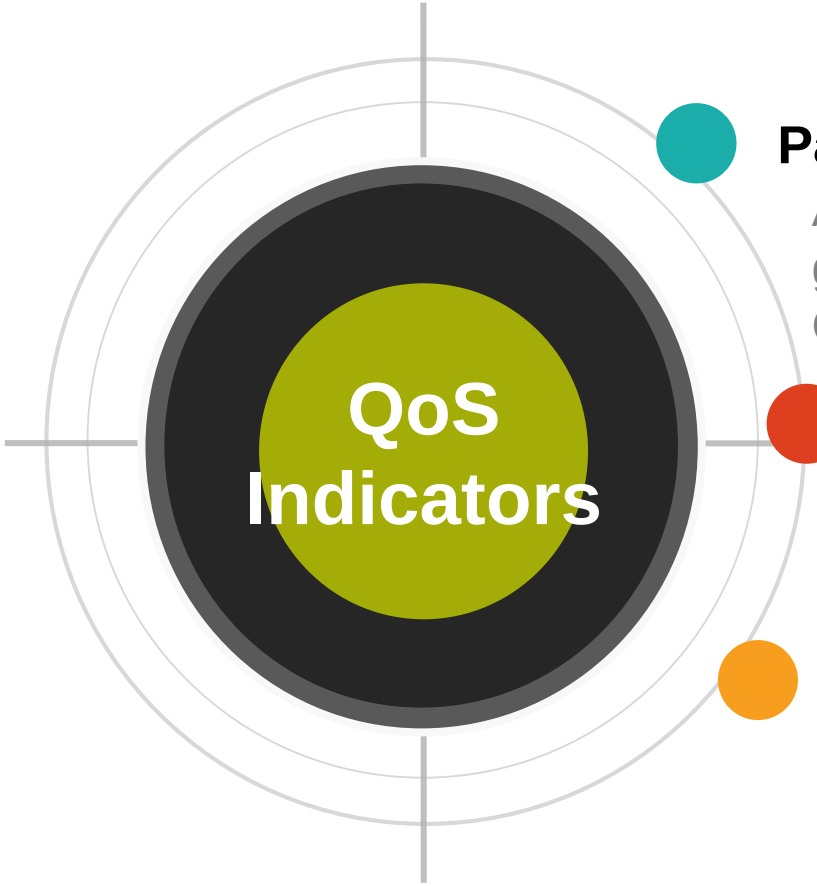


Fig. Fiber-wireless Hybrid Illustration

I. INTRODUCTION



Packet delay

Affected by the number of ONUs, generated due to packet queuing at ONU nodes.

Packet error probability

Affected by the distributions of ONUs, is an indicator of network reliability.

Packet loss rate

Affected by the number of ONUs, generated due to network congestion.

According to the requirements of delay and reliability of the traffic, three main QoS indicators are selected: packet delay, packet error probability and packet loss rate.

II. SYSTEM MODEL

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- To avoid fierce competition, sensors are divided into several groups.
- Each group is configured with an ONU as a converge node to gather data.
- ONU converges the information from sensors and send it to the OLT.

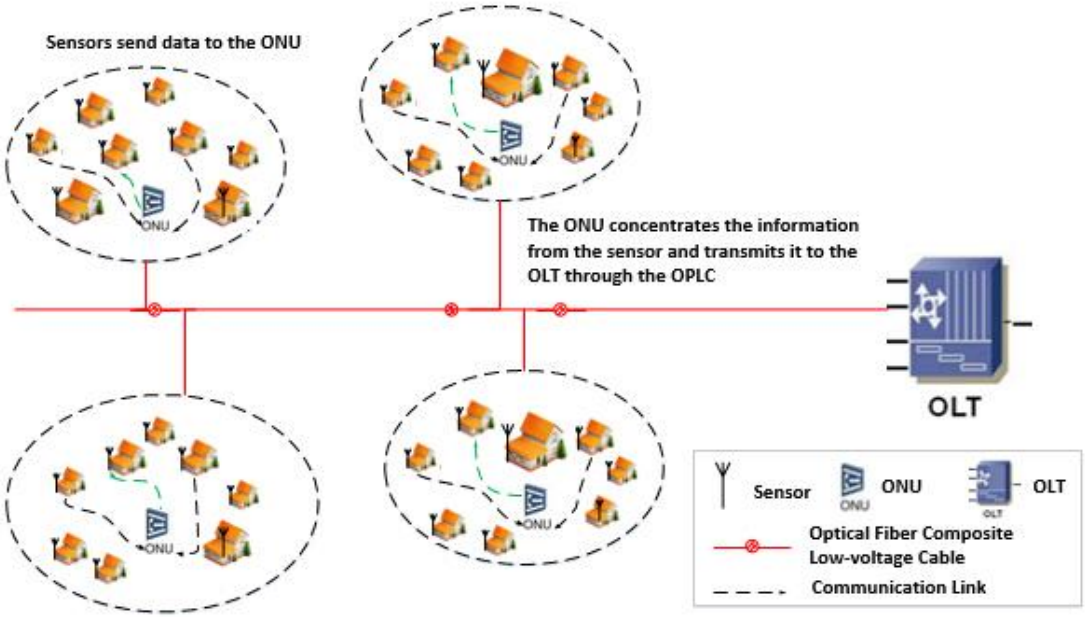

Fig. System Model

II. SYSTEM MODEL

1 Number Planning Model

Fig. Number Planning Illustration

A. packet delay

$$T = \overline{S} + \frac{\lambda \overline{S^2}}{2(1-\rho)} \le \overline{S} + \frac{\lambda_{\max} \overline{S^2}}{2(1-\rho)} \le T^*$$

B. Packet error probability and packet loss rate

$$T = \overline{S} + \frac{\lambda \overline{S^2}}{2(1-\rho)} \le \overline{S} + \frac{\lambda_{\max} \overline{S^2}}{2(1-\rho)} \le T^*$$

$$N \ge \frac{1}{\pi}\left(\frac{\frac{\gamma^*}{\phi}\sigma^2 \ln\left(1/R^*\right)^{\alpha/2}}{1-\ln\left(1/R^*\right)^{\alpha/2}\gamma^* N^{-\alpha/2}\zeta\left(\alpha/2\right)}\right)^{2/\alpha}$$

Based on QoS requirements of a network, the number of ONUs in a certain area is solved by a series of mathematical methods such as queuing theory.

2 Location planning model

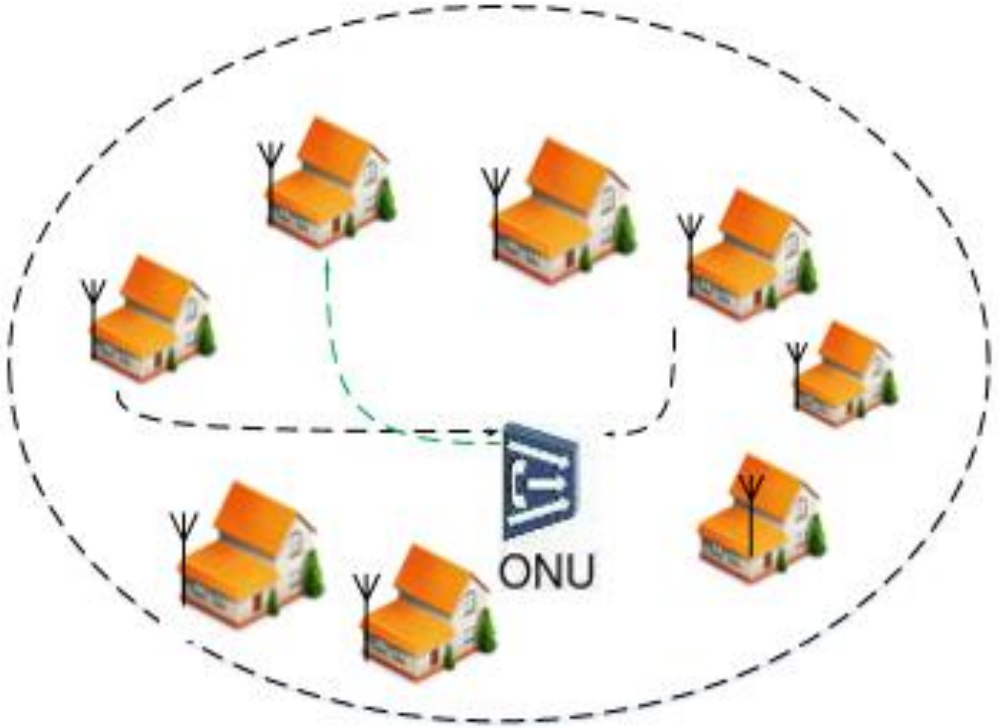

Fig. Location Planning Illustration

A. Optimization objective

- Total power consumption of all ONUs

B. Restrictions

- Constant ONUs number
- Load balancing

$$F = \min(E) = \min(u \sum_{n=1}^{N} \sum_{m=1}^{M} c_{n,m} * d^{2}_{n,m})$$

$$s.t.(1-\psi)\left\lfloor \frac{M}{N} \right\rfloor \le \sum_{m=1}^{M} c_{n,m} \le (1+\psi)\left\lfloor \frac{M}{N} \right\rfloor, n = 1,2,...N$$

III.ALGORITHM DESIGN

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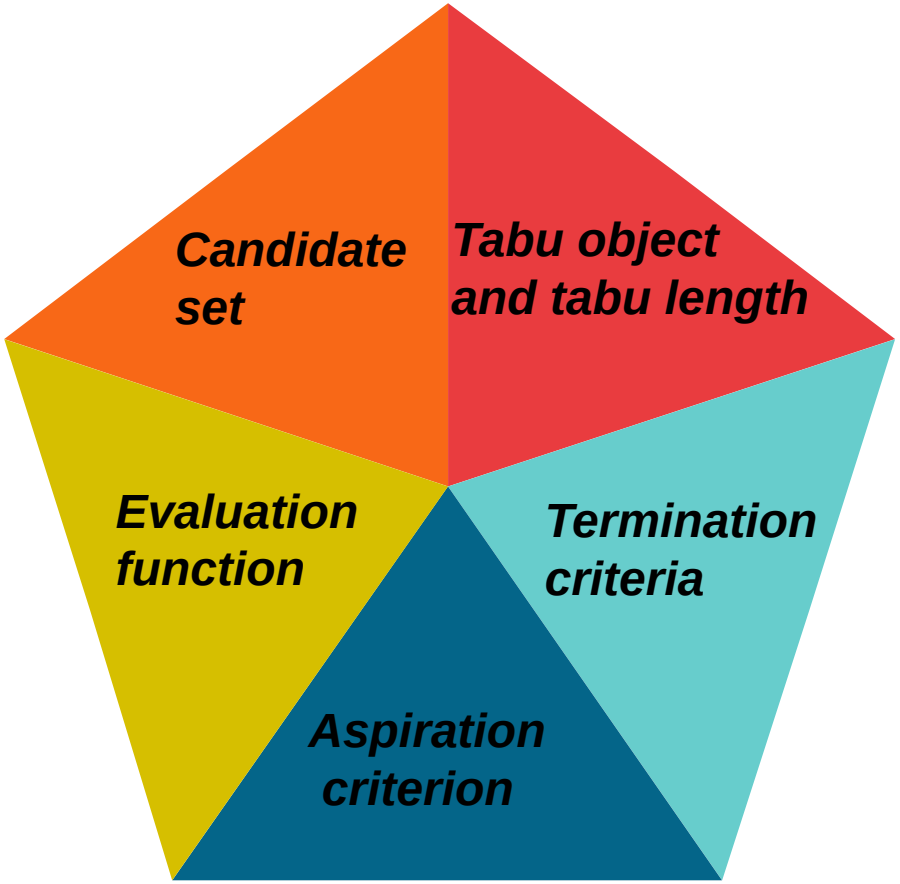

- **Tabu search (TS) algorithm** is a heuristic algorithm.
- Introducing a **tabu list** and a corresponding **tabu criteria** to record the optimization process.
- Achieve **global optimization**.

III. ALGORITHM DESIGN

- **Aiming at the lowest power consumption of ONUs, a tabu-search-algorithm-based ONU location planning method (TOLPM) is proposed.**
- **The steps are as follows:**
  - **First, set the initial solution and initial tabu list.**
  - **Second, if the solution satisfy the aspiration criteria, then put it into the tabu list.**
  - **Third, select the optimal solution that is not taboo and put it into the tabu list.**
  - **Last, if the termination criteria is satisfied then end the algorithm.**

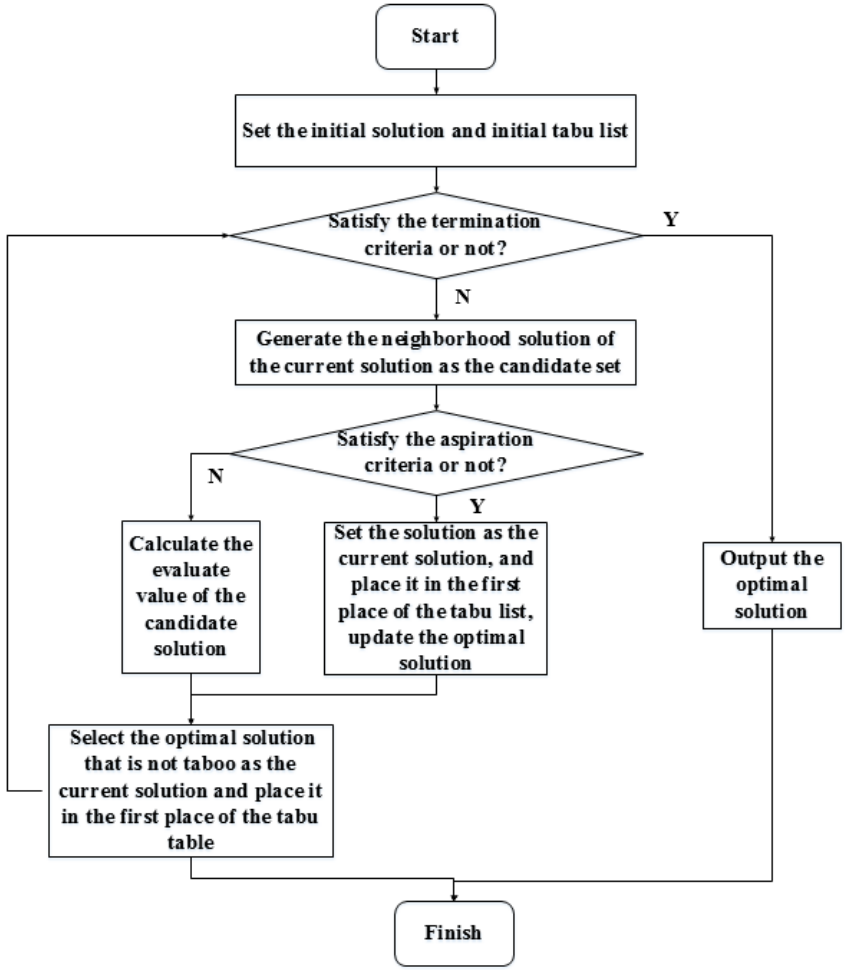

Fig. Flow chart of TOLPM

IV.EVALUATION RESULTS

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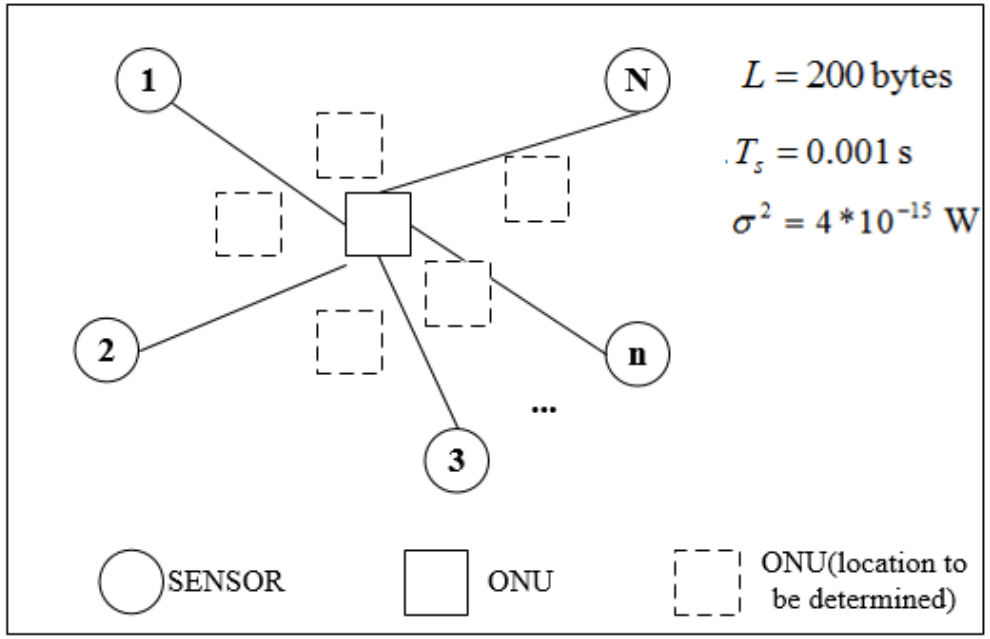

Fig. Topology in the experiment

TABLE I. RELATED PARAMETERS AND OPTIMAL PLANNING SCHEME

The number of sensors	100		
The number of ONUs	3		
QoS metrics	$T^* = 0.5s$	$P_e^* = 0.005$	$R^* = 0.01$
The number of sensors in each group	35	32	33
Coordinates of ONU	(274,789)	(406,343)	(867,538)
Total power consumption	$5.86mW$		

- **In the experiment, 100 sensors and three QoS metrics are set. Through number solving process, it is found that 3 ONUs is needed to cover 100 sensors.**
- **Through ONU location planning method , the coordinates of ONUs are determined. Total power consumption is obtained correspondingly.**

IV. EVALUATION RESULT

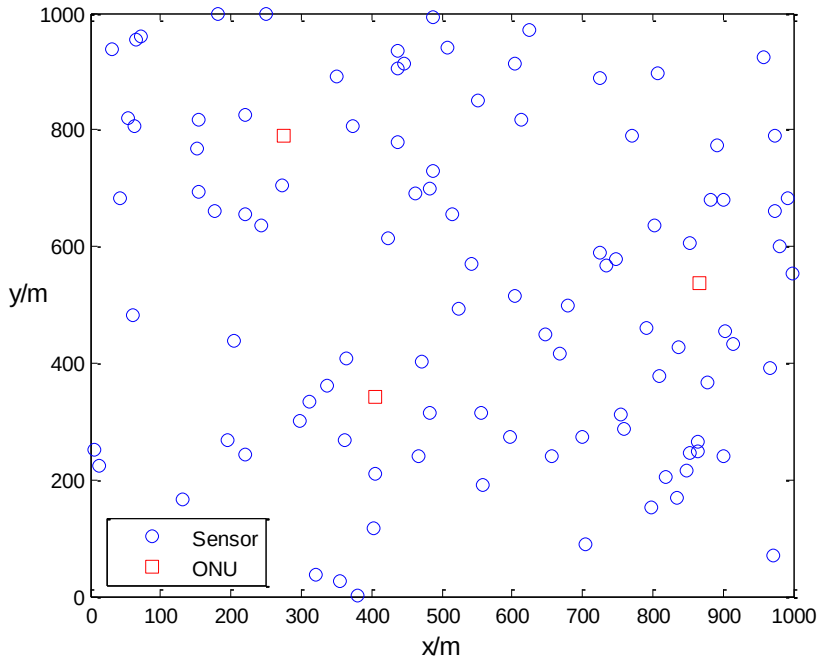

Fig. Optimal ONU Planning Scheme Illustration

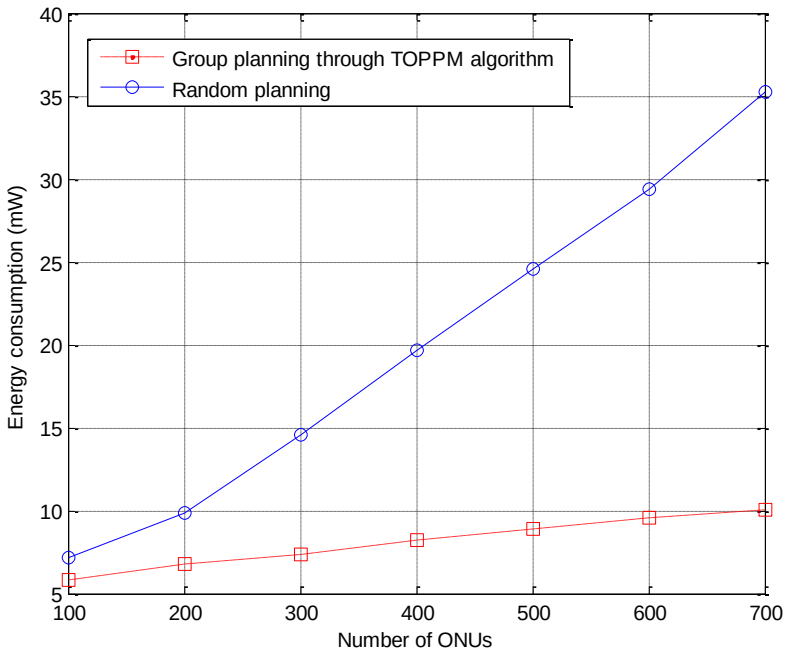

Fig. Total Power Consumption

- **By comparing power consumption before and after planning, total power consumption has decreased 14.29% when 100 ONUs are set. If more ONUs are set, the percentage is much bigger than that.**

V. CONCLUSION

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Some contributions

- ✓ Find the minimum number of ONUs and optimize their locations.
- ✓ Guarantee the QoS of the network and save energy efficiently.
- ✓ Guide the planning of EPON-based smart grid communication networks.

Future outlook

Consider sensors to be relay nodes thus the system model will become a multi-hop network. Add some restrictions, research the position setting and data routing problems.

THANK YOU!