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汇报

LoRa组网综述：研究问题、当前解决方案和未决问题

王昊

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01

介绍

INTRODUCTION

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Internet-of-Things

IoT

Robust Operations

Humidity

Temperature

Wider Coverage

Large Geographical Area

High Energy Efficiency

Mostly Battery Powered

Conventional Technologies

Zigbee

Bluetooth

Shorter Range

LPWAN Technologies

Cellular-IoT Technology

Based on Cellular Infrastructure

Lora Networking

Autonomous

Without Third-Party Infrastructure

Proprietary Networks

Autonomous

With Third-Party Infrastructure

Cellular-IoT Technology

Advantages

Wide Area

Densely Populated

Higher QoS

Disadvantages

Energy Inefficiency

Heavy Interference

Types

LTE-M

NB-IoT

EC-GSM

Proprietary Networks

Advantages

Link Budget

Coverage

Vendors Traction

Disadvantages

Closed Source

Low Security

Downlink Restriction

Types

SigFox

Ingenu

Weightless

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Lora Networking

Advantages

Open Source

Over the Air Update

Low Cost

Immune to Interference

Higher Payload

Encryption and Authentication

Applications

Smart Buildings

Smart Cities

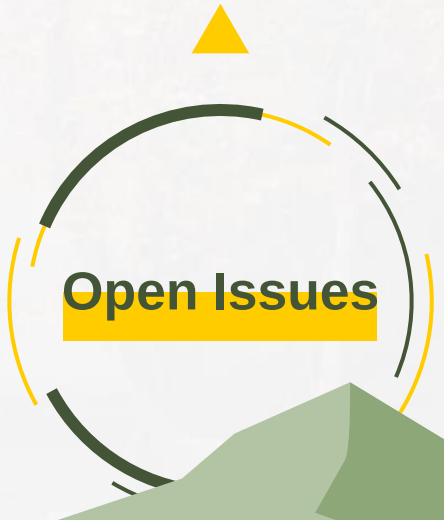
Smart Agriculture

Differences

Devise a Taxonomy for Problems
Upper Layers Discussed
Recent Performance Measurements

Recent Technical Advancements

Further Improve Performance



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02

LORA的简要技术背景

TECHNICAL BACKGROUND

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LoRa Stack

Sub-GHz ISM Band

LoRa

Physical Layer :

Chirp Spread Spectrum

LoRaWAN

MAC Layer :

ALOHA : Exponential Back-Off

TDMA : Time-Slot

Chirp Spread Spectrum

Frequency Varies Linearly within the Available Bandwidth

Spreading Factor

Time on Air

Number of Data Bits

Bandwidth

Data Rate

Code Rate

Resilience to Noise

LoRa System

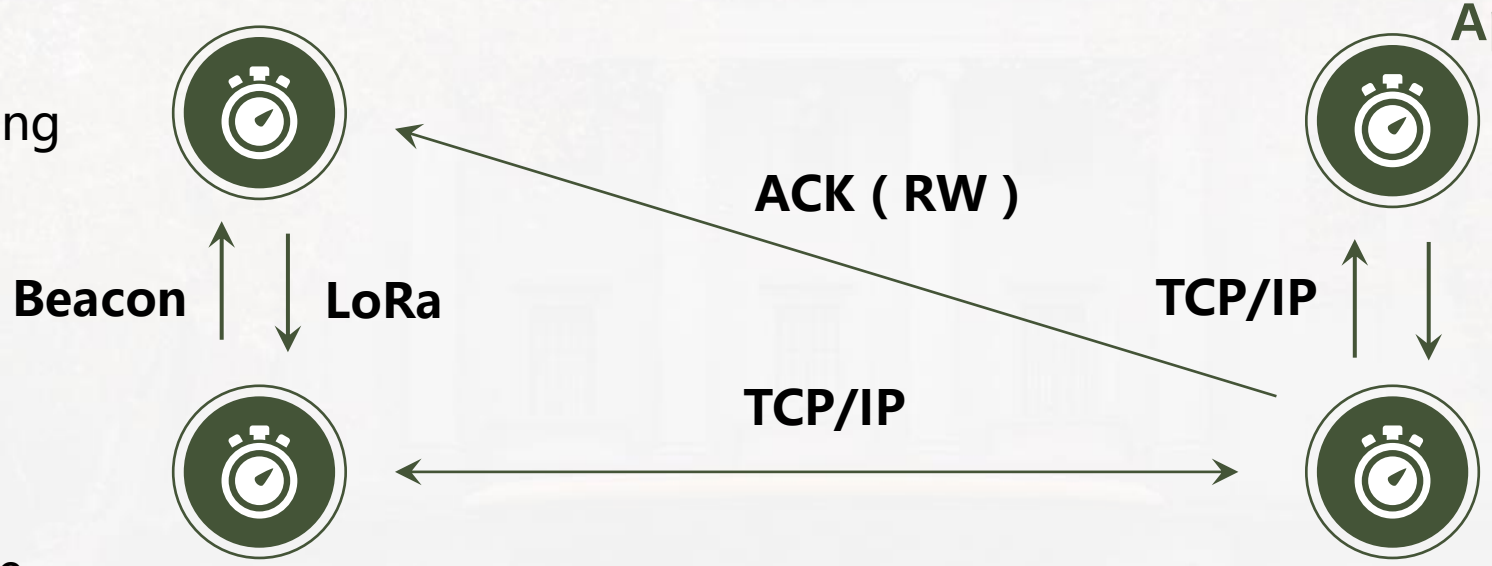
Architecture

End Devices

Three Operating Modes

Gateways

Forwarders
Relay Message



Application Servers

Process Messages

Network Servers

Make Decisions
Direct Message

Unique Properties

Ultra-Long Distance

Line-Of-Sight Communication

SF、TP、CR、PRR

Long Lifetime of Nodes

Duty Cycle

Low Cost and Complexity Device

Channel Activity Detection

Reduce Overheads : No Signalling

Concurrent Reception of Gateways

Orthogonal SF

Robustness to Doppler Effect

Doppler Effect

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LORA网络的现有部署

EXISTING DEPLOYMENTS

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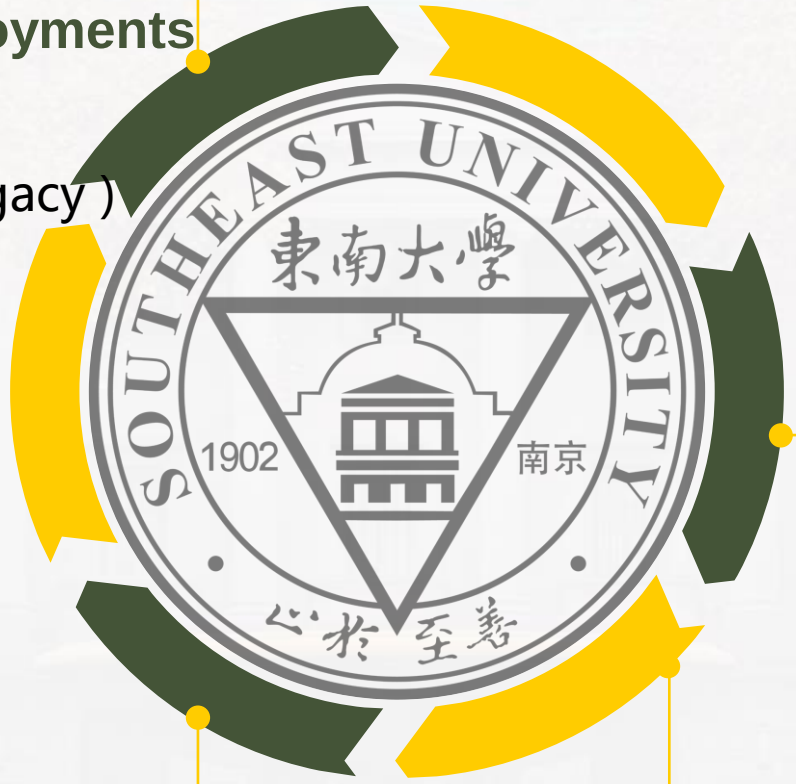
EXISTING DEPLOYMENTS

Smart Cities and Urban Deployments

Waste Management
Monitor Solar Power Plants (Legacy)
Power Monitoring

Smart Meters

Smart Metering Applications



Smart Golf Course

Sensor of Golf Cart

Smart Islands

Reports Water Quality

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研究问题的分类

TAXONOMY

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Energy Consumption

Energy Efficiency

Improve the Longevity of End-Devices
Unavoidable Circumstances

End-Device Operations

Micro-Controller Operations
Wireless Transmissions

Techniques

Consume Instantaneous Bandwidth
Light MAC Protocols

Communication Range

Technology

Rudiment

Chirps Spread Spectrum

Challenge

Signal Attenuation

Propagation Losses and Fading

Gateways Decode Signals

Estimating the Coverage

Anisotropic

Unexplored Mathematical Models

Multiple Access

Aim

Confined Region and Spectrum
Share Limited Spectrum Concurrently

Link Coordination

Scheduler : ALOHA / TDMA
(Cannot Handle Collisions)

Resource Allocation

Vary Parameters
Dynamic Deployed Environment

Error Correction

Existing Schemes

Hamming Code
Spreading Factors
(Data Corruption)

Channel Coding

DaRe : Application Layer
Redundant Data
(Bursty Packet Loss)

Interference Cancellation

Extract Collided Signals
(Inadequate Number)

Security

Security Key Attacks

Eavesdropping
Selective Forwarding
Node Impersonation

Current Key Technology

AES-128 Bit Encryption
Never Update Key

Requirements

Key Generation
Key Update Mechanism
Third-Party Authorization

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当前解决方案

CURRENT SOLUTIONS

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Energy Consumption

Backscatter Signals

PLoRa

LoRea

LoRa Backscatter

Wireless Power Transfer

Not Feasible For
Hardware Extensions

Ambient Energy

PLoRa : Passive RF Chips

Weak Signals

Avoid Retransmission

Detect but Not Decode

More Gateways

Dynamic Allocation

Communication Range

Sparse End-Device Placements

Less Packet Loss

Weak Signals

Cloud (Cannot Be Decoded)

Programmable Hardware

More Gateways

1 Device : N Gateways

Improve Network Density

Cheap Radios

Carrier Frequency Intrinsic Property

Disentangle Collided Signals

(Radio Imperfections)

Integrate LPWANs

‘ GUN Radio ’ Experimented

Commercial Device Ambiguous

Error Correction

Channel Coding

Drake : Redundant Information

(Difficulty to Create Degree of Distribution)

(Increase Number of Collision)

Interference Cancellation

Carrier Frequency Intrinsic Property

Disentangle Collided Signals

(Only 5-10 Devices Concurrently)

Distributed Error Correction Tech Proposed

Additional Preambles

Ideal-CSMA : Low PRR (Synchronously)

CSMA-CAD : SF Randomized, PRR Doubled

RS-LoRa

Coarse-Grained Information

Parameter Combination

Network Density

Retransmission Scheme

Theoretically Proven

Data Compression

Channel Coding

Multiple Access

Link Coordination

Network Density

More Gateways (Directional Antennae)

Assign Dynamic Parameter

ADR

Adaptive Data Rate

Data Rate

Channel Allocation

Energy Consumption

Performance

Deployed Environment

Genetic Algorithm

Usage of ACKs

Multiple Access

Resource Allocation

LoRa Security

Attacks

RF Jamming
Replay
Beacon Synchronization

Third-Party Authorisation

Key Generated both
Application and Network

Vulnerabilities

Encryption Keys : Physical Access

Key Generation

Join Request : DevNonce
Random Number Generator Algorithm
(Incompatible with LoRaWAN specification)

Blockchain Mechanism

Computationally Difficult
Large Scale Deployments
Low Powered Devices

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未决问题

OPEN ISSUES

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OPEN ISSUES

Placement of Gateways

Categories of Applications

Link Co-ordination

Dynamic Retransmission Policies

（Downlink ACK）

Communication Range

LoRa Chips Evolve

Light Modifications of Chips

Security

Each Deploying Applicatsion

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结论

CONCLUSION

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Structure

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感谢老师

Thanks For Listening

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