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Nessum In Flat Environment

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Overview

Agenda

- Introduction to Power Line Communication (PLC)
- Apartment Building-Level Applications
- Individual Flat Applications
- PHY Layer Specifications
- MAC Layer Details
- Test Setup in Apartment Environment
- Performance Analysis
- Key Findings
- Recommendations for Implementation
- Q&A

Introduction

Introduction to Power Line Communication

- Technology that enables data transmission over existing power cables
- Leverages infrastructure that's already in place
- Two main categories:
  - Narrowband PLC (NB-PLC): 3-500 kHz, data rates up to 1 Mbps
  - Broadband PLC (BB-PLC): 1.8-200 MHz, data rates up to 1 Gbps
- Standardized by IEEE 1901, Nessum, ITU-T, and PRIME/G3-PLC

Applications

Apartment Building-Level Applications

Use Case	Description	Benefits
Smart Metering	Automated meter reading for electricity, water, and gas consumption for all units in the building	• Eliminates manual meter reading • Real-time consumption monitoring • Facilitates accurate billing
Building Management Systems	Centralized monitoring and control of building-wide systems including HVAC, lighting, and security	• Reduces operational costs • Improves energy efficiency • Centralized management interface
Elevator Monitoring	Remote diagnostics and monitoring of elevator systems	• Faster response to failures
Common Area Access Control	Electronic access control for lobbies, parking garages, and amenity spaces	• Enhanced security • Access logs • Remote management
Video Surveillance	Networked CCTV system monitoring common areas	• Security monitoring
EV Charging Infrastructure	Networked management of EV charging stations in parking areas	• Billing integration • Load balancing • Usage monitoring
Emergency Systems	Fire alarm, emergency lighting, and evacuation systems communication	• Critical safety infrastructure • Centralized monitoring • Meets building code requirements
Solar/Renewable Management	Monitoring and control of building solar panels or other renewable energy systems	• Energy production monitoring • Performance optimization • Integration with building power management

Applications

Individual Flat Applications

Use Case	Description	Benefits
Smart Home Automation	Networked control of lights, appliances, and environmental systems within a flat	• Energy savings • Remote control via app
IPTV and Streaming	Video distribution to multiple TVs within a home	• Content sharing across rooms • VOD services
Home Office Networking	Reliable internet connectivity for work-from-home setups	• Stable connection • Coverage in all rooms • Secure network extension
In-Home Health Monitoring	Connected healthcare devices for monitoring elderly or patients	• Aging in place support • Continuous health monitoring • Alert systems
Home Security Systems	Connected alarm systems, cameras, and motion sensors	• Remote monitoring • Alert notifications • Integration with smart locks
Smart Kitchen Appliances	Networked refrigerators, ovens, coffee makers, etc.	• Remote control and monitoring • Usage analytics • Maintenance alerts • Recipe sharing
Energy Management	Monitoring and optimizing power consumption within the flat	• Real-time usage monitoring • Appliance-level consumption data • Automated efficiency adjustments

Applications

Comparison With other standards

Use Case / Application Area	Nessum (HD-PLC)	G.hn (ITU-T G.9960/61)	HomePlug AV	LonWorks (PLC)
Smart Metering / AMI	✅ Widely used (multi-hop, Japan, EU)	✅ Supported	⚠️ Limited	✅ Basic support
In-building High-Speed Networking	✅ Excellent (HD video, surveillance)	✅ Ideal (up to 1–2 Gbps)	✅ Legacy option	❌ Not designed for this use
Home Automation / IoT	✅ Supports many IoT devices	✅ Especially with mesh extension	✅ Partial	✅ Designed for automation
Street Lighting / Outdoor Infra	✅ Good (multi-hop over long distances)	✅ Possible with proper nodes	❌ Distance-limited	✅ Deployed in several cities
HVAC and Lighting Control	✅ Possible (via IP bridging)	✅ If integrated with control layer	❌ Not common	✅ Primary application
Retrofit Installations	✅ Ideal (no new wiring required)	✅ Especially in MDU or dense buildings	✅ Popular historically	✅ Common legacy usage
Surveillance / IP Cameras	✅ Suitable for PoC + data (with filters)	✅ High-speed support	✅ Moderate performance	❌ Not supported
Electric Vehicle Charging Infra	✅ Possible (charging bay + control)	✅ With proper shielding	❌ Not recommended	❌ Not supported
Distance / Coverage	✅ Up to kilometers with multi-hop	✅ ~500m typically	⚠️ ~300m max	⚠️ ~200m max

Technology

PHY Layer Specifications

Feature	Nessum (HD-PLC)	G.hn (ITU-T G.9960/61)	HomePlug AV	LonWorks (PLC)
Modulation Technique	Wavelet-OFDM	FFT-OFDM	FFT-OFDM	FSK, BPSK, SPSK
Operating Frequency Band	2–28 MHz (XB1); up to 56 MHz (XB2/XB4); 150-500 kHz (narrowband)	2–100 MHz	2–30 MHz (AV); 1.8-86 MHz (AV2)	125–140 kHz
Data Rate (Max)	~100 Mbps (XB1), up to 1 Gbps (multi-hop XB4)	Up to 2 Gbps (coax), ~1 Gbps (powerline)	Up to 200 Mbps	~5.4 kbps
Channel Bandwidth Options	2 MHz (narrow), 10 MHz, 20 MHz, 26 MHz, 56 MHz (multi-mode)	5 MHz, 14 MHz, 28 MHz, 50 MHz, 100 MHz	~28 MHz (fixed)	~15 kHz (fixed)
Modes Supported	XB1 (SISO), XB2 (MIMO), XB4 (multi-hop & extended freq); IEEE 1901c-2024 compliant	Baseband, Coax, Phoneline, Powerline (multi-mode)	HomePlug AV, AV2 (AV2 supports MIMO)	ANSI/CEA-709.2 compliant modes
Error Correction	Reed-Solomon + Convolutional Coding	LDPC + Convolutional Coding	Turbo + Reed-Solomon	CRC only
Security at PHY	AES-128/256; IEEE 802.1X authentication	AES-128	AES-128	Basic Encryption
Interference Handling	Adaptive tone allocation, subcarrier masking, frequency notching	Notch filtering, PSD shaping, MIMO	Adaptive tone mapping, PSD shaping, MIMO (AV2)	Frequency hopping (optional), Adaptive data rates
Topology Support	Point-to-point, Star, Mesh, Multi-hop	Star, Tree, Mesh, P2P	Star, Tree, P2P	Star, Bus, Free topology

Technology

MAC Layer Details

Feature	Nessum (HD-PLC)	G.hn	HomePlug AV	LonWorks (PLC)
Medium Access Control	CSMA/CA + DVTP (Dynamic Virtual Token Passing)	TDMA + CSMA/CA (with coexistence support)	CSMA/CA+ Beacon-based TDMA	Token-based scheduling + CSMA (optional)
QoS Support	Yes (8 priority levels via DVTP)	Yes (4 traffic classes, configurable weights)	Partial (4 traffic classes, CAPs/CPs)	Basic (acknowledge service levels)
Multi-Hop Routing	Yes (ITU-T G.9905, up to 10 hops)	Yes (ITU-T G.9961 mesh extension)	No (AV); Limited in AV2	Yes (basic repeaters)
Addressing Scheme	Logical addressing (up to 1024 nodes)	Domain ID + Node ID (logical addressing)	MAC-based + Network ID	Domain/Subnet/Node ID hierarchy
Error Handling	ARQ + Selective Repeat	HARQ (Hybrid ARQ) + Selective retransmission	ARQ + Selective Repeat	Acknowledged/Unacknowledged service
Broadcast/Multicast Support	Yes	Yes	Yes	Yes
Power Saving Features	Sleep scheduling + Low power modes	L2/L3 power management	Limited	Not supported
Security at MAC	AES Key Management + IEEE 802.1X + Secure Join	Secure Handshake + AES Key Exchange + EAP	Pre-shared Key or Pairing	Authentication + Encrypted Frames
Network Management	Automatic network formation and healing	Centralized Domain Master control	Central Coordinator (CCo) based	Centralized or peer-to-peer

Performance Testing

Test Objectives & Environment

- Evaluate HD-PLC performance in residential environment
- Benchmark key parameters:
  - Data rate (PHY & MAC layer)
  - Signal strength across components
  - Performance across phases (R, Y, B)
  - Cross-flat signal penetration
- Test setup mimics two flats with:
  - 3-phase electrical wiring
  - Standard residential components
  - Variable cable lengths (10m-50m)

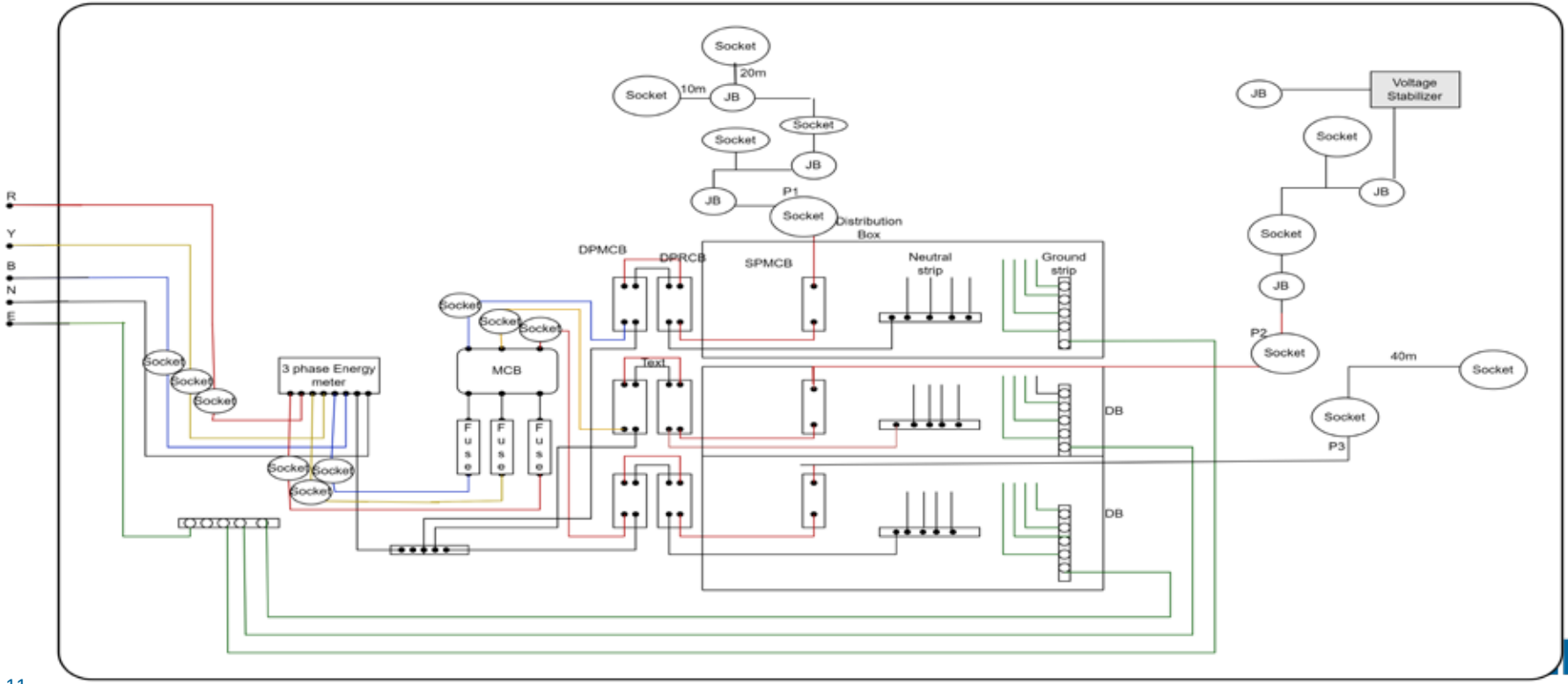
Performance Testing

Test Setup & Performance Evaluation

- Electrical Components Tested
  - MCB (Master Circuit Breaker)
  - Energy Meter
  - DPMCB/DPRCB
  - SPMCB
  - Junction Box
  - Voltage Stabilizer (help in testing the behavior due to induction circuit)
- Test Configurations
  - Individual component impact assessment
  - Cumulative effect of component chains
  - Cross-phase communication performance
  - Variable cable length testing (10m, 20m, 40m, 50m)
- Measurement Methodology:
  - Tests measure data rate reduction at both PHY layer (111 Mbps max) and MAC layer (54 Mbps max) to quantify impact of each component and configuration on PLC performance.

Performance Testing

Test Setup – Flat environment



Performance Testing

PLC Test Report in Apartment Environment - 1

- Maximum PHY Rate: 111 Mbps
- Maximum MAC Layer Data Rate: 54 Mbps
- Tool Limitation: Unable to calculate Signal Strength Loss between Tx and Rx. Tests performed to determine PHY and MAC layer data rates.
- Emulated Flat Environment
  - Impact due to Energy Meter
    - PHY Layer Data Rate loss: 4 – 5 Mbps
    - MAC Layer Data Rate loss: 10 Mbps
    - MAC Layer Data Rate loss between R and Y phase: 2 - 3 Mbps
    - MAC Layer Data Rate loss between R and B phase: 5 - 6 Mbps
  - Impact due to Energy Meter and MCB and RCCB
    - PHY Layer Data Rate loss: 6 - 8 Mbps
    - MAC Layer Data Rate loss: 10 - 14 Mbps
    - MAC Layer Data Rate loss between R and Y phase: 2 - 4 Mbps
    - MAC Layer Data Rate loss between R and B phase: 6 - 8 Mbps
  - Impact due to RCCB + 50 m Cu wire
    - PHY Layer Data Rate loss: 4 – 5 Mbps
    - MAC Layer Data Rate loss: 20 - 22 Mbps
    - MAC Layer Data Rate loss between R and Y phase: 4 - 8 Mbps
    - MAC Layer Data Rate loss between R and B phase: 6 - 10 Mbps

Performance Testing

PLC Test Report in Apartment Environment - 2

- Actual Flat Environment
  - Within Flat (Between rooms) MAC Data rate: 35 – 44 Mbps
  - Between adjacent Flats MAC Data Rate: 3 – 7 Mbps
- General Observation
  - Data Rate Loss due to different phase is 2 – 6 Mbps
  - No significant data rate loss due to 1 phase Voltage Stabilizer
  - Within Flat environment data rate varies from (54 – 30 Mbps)
  - Significant level of Signal between 2 Actual flats (MAC layer data rate observed around 3 – 7 Mbps)

Question and Answer

- Questions?