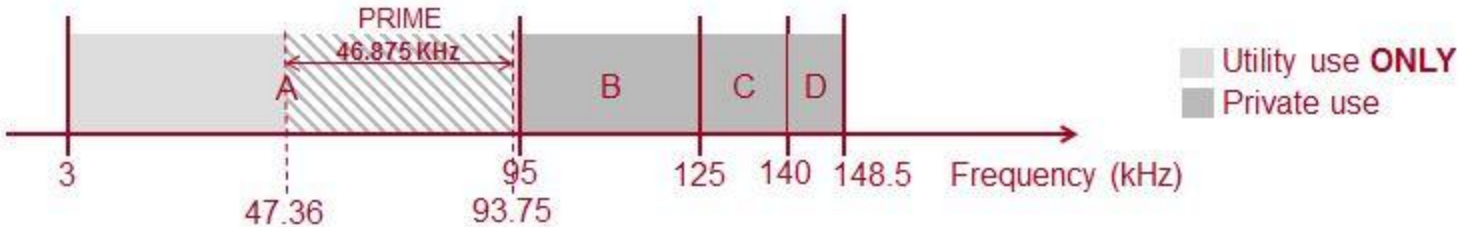
Physical Layer : Usage Spectrum

- **Signal resides in CENELEC – "A" band**
  - Ensures universal regulatory conformance
- **46.875 KHz wide signal**
  - Spanning from 47.36 KHz to 93.75 KHz
- **Lower end (3 - 47.36KHz) not used because**
  - Lower impedance, specially at transformer bus-bars
  - More unpredictable behavior in meter rooms owing to higher impact of household appliances on these frequencies



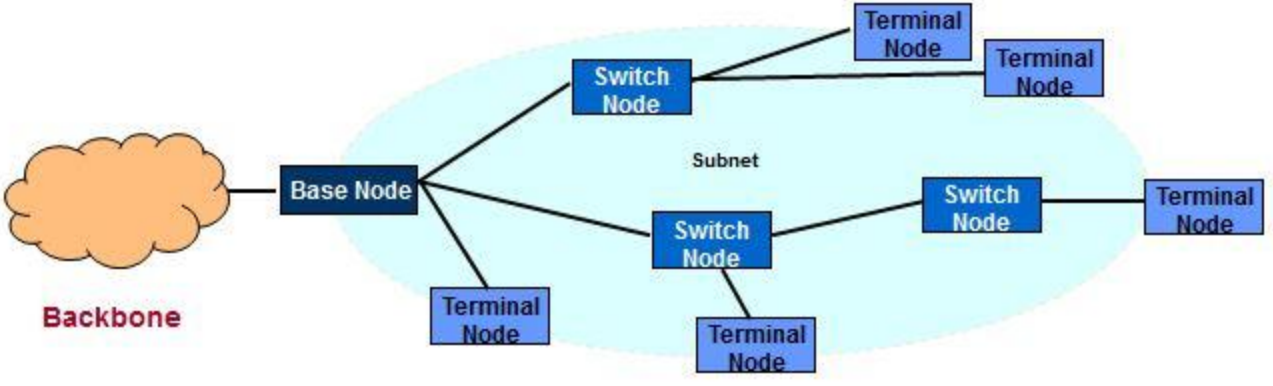
Physical Layer : Salient featuers

- OFDM based PHYSICAL layer with 96 subcarriers +1 pilot
- Modulation in 3 possible constellations : ***DBPSK, DQPSK & D8PSK***
- Rate ½ support for each modulation scheme to enhance robustness
- Symbol time = 2.24 msec

PHY characteristic	DBPSK		DQPSK		D8PSK	
Convolutional Code (1/2)	On	Off	On	Off	On	Off
Bits per subcarrier	0.5	1	1	2	1.5	3
Bits per OFDM symbol	48	96	96	192	144	288
Raw data rate (kbps approx)	21.4	42.9	42.9	85.7	64.3	128.6

MAC Layer : System Concept

- **Network is made up of independent "subnets"**
- **Each "subnet" is comprised of one** *Base Node* **& several** *Service Nodes*
- **Base Node :**
  - Sets up and maintains the subnet
  - Provides point of connectivity to network
- **Service Nodes maybe of type**
  - "*Terminal Nodes*", which are network end-points
  - "*Switch Nodes*", which perform Repeating function in addition to "*Terminal Node*" functions



MAC Layer : Salient features (1/2)

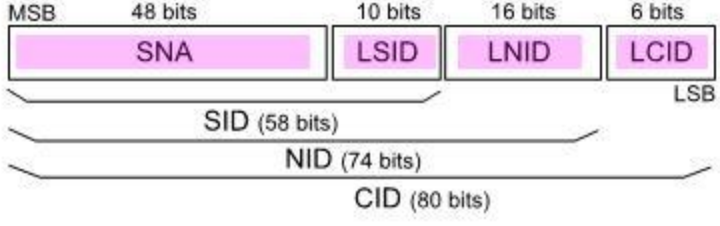
- **Option for both contention-based and contention-free channel access**
  - Contention-base period provides faster reaction time to short real-time uplink data
  - Contention-free period enables collision free transport of bulk data
- **Automatic transition between Terminal and Switch/Repeater functions**
  - Automatic scalability based on network conditions
  - Truly plug-and-play. No network planning required
  - Easy to extend network inside home for Home-Automation (future extension)
- **Bulk of complexity is in Base Node**
  - Facilitates low cost repeating function
  - All devices can implement Switch/Repeating function

MAC Layer : Salient features (2/2)

- **Native support for Multicasting**
  - Devices of a particular type may form a multicast group
  - Efficient software upgrade possibility
- **"Selective ARQ" mechanism**
  - To provide an efficient repetition mechanism in adverse channel conditions
- **Robust security framework**
  - Privacy : provided through 128 bit AES encryption
  - Authentication : Secrecy of encryption key

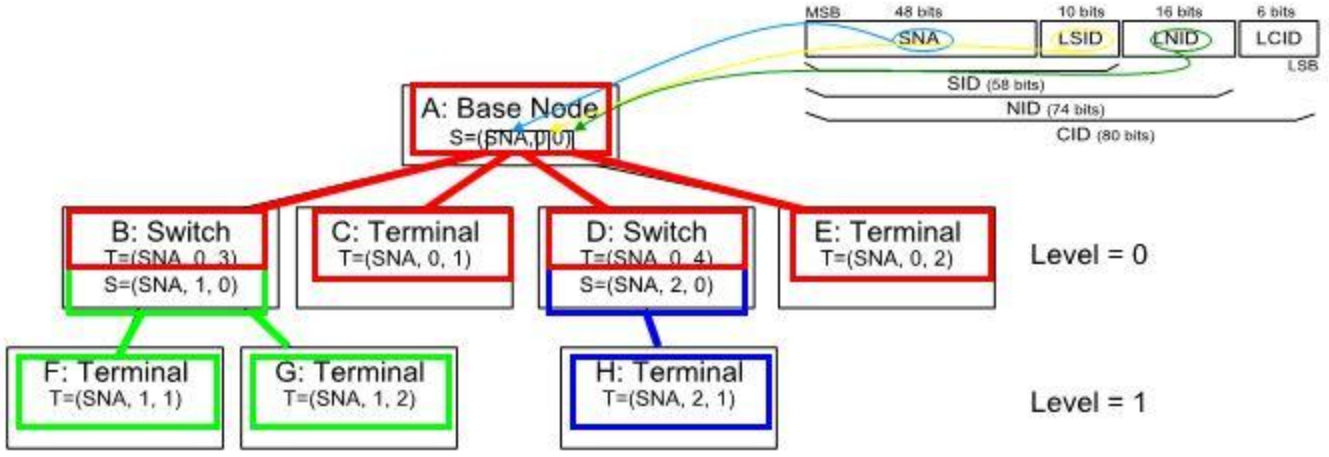
MAC Layer : Addressing (1/2)

- Each subnet has a unique MAC address (IEEE 802-2001)
- MAC address of Base Node is the Subnetwork Address (SNA)
- Addressing is performed down to individual connections within a device
- A complete address is 80 bits long and is comprised of
  - Subnetwork Address (SNA)
  - Address of Switch to which a device is associated
  - Address of the device itself
  - Id of the connection end-point



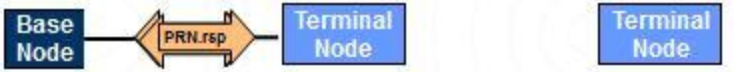
MAC Layer : Addressing (2/2)

- Switch devices maintain 2 different addresses, one for Terminal function and other for Repeating function



MAC Layer : Network Setup & Scaling

- **Base Node transmits** *Beacons*
- **Newly powered-up devices listen for** *Beacons*.
- **On receiving** *Beacons*
  - **Request** *Registration* **(allocation of NID)**
  - **Make one or more** *Connection* **requests (allocation of CID)**
- **On not receiving Beacons**
  - **Broadcast "***Promotion Required***" (PRN) message**
  - **Receiving "Terminal Nodes" make** *Promotion* **request to Base Node**
  - **Base Node accepts the request & allocates SID to use**
  - **Terminal transits to Switch functional state & starts transmitting** *Beacons*
  - **Terminal makes** *Registration* **&** *Connection* **requests to Base via Switch**



MAC Layer : Channel Access

- Time is divided into FRAMEs
- FRAME is always 280 symbols (627 msec) long
- A FRAME is comprised of at least 1 Beacon and 1 Shared Contention Period
- It may optionally contain more Beacon periods (up to 5) & a Contention Free period
- Beacon contains administrative information on:
  - Number of Beacons contained in Frame
  - Length of Shared Contention Period
  - Usage information of Contention Free Period (if present)