1. **MAC Addressing**
   - It is used by network adapters to uniquely identify themselves. 12-digit hexadecimal numbers.

2. **Binary Exponential Back-off Algorithm (BEB)**
   - It achieves congestion control by dynamically choosing the contention window. It works as follows:
     1. Each station draws a random number from range (0, C) and backoffs for duration \(2^x\) slot-time, \(x\) called contention windows.
     2. After expiry of the back-off interval, a station transmits its data frame if the medium is free. \((C = 1)\)
     3. If there are large number of stations trying to access the transmission medium, collisions take place and back-off windows are exponentially doubled every time. \((C = 2)\)

3. **Distributed Random Access Schemes/Contention Schemes**

4. **For data services**
   - **Aloha**
     - The basic idea is applicable to any system in which uncoordinated users are competing for the use of a single shared channel.
   - (1) **Pure Aloha**
     - Users can transmit whenever they have the data. To determine whether a transmission was successful, a sender waits for an acknowledgment from the receiver for a time period. If no acknowledgment is received, the message will be sent again.
     - **Advantages** - simplicity, no synchronization is required.
     - **Disadvantages** - collision of packets.
   - (2) **Slotted Aloha**
     - Time is divided into slots, and users are allowed to transmit at specific instances of time.
     - **Advantages** - simple to implement, highly decentralized.
     - **Disadvantages** - collision waste slots, idle slots.
For Local Area Networks:

- **CSMA (Carrier Sense Multiple Access)** protocols -

  A station senses the carrier on the channel before starting its own transmission. When the channel is sensed to be idle, a station can take one of the three different approaches to transmit a packet on to the channel. These three protocols are:
  1. **Non-persistent CSMA** - Wait random period of time then check for availability
  2. **Persistent CSMA** - Monitor the channel continuously and when it is available, it transmits the data
  3. **p-persistent CSMA** - When a station becomes ready to send and it senses the channel to be idle, it either transmits with a probability p or it defers transmission by one time slot with a probability q = 1 - p. If the deferred time slot is idle, the station either transmits with probability p or defers again with a probability q. This process is repeated until either packets are transmitted or the channel becomes busy.

- **CSMA/CD (Collision Detection)** -

  If a collision is detected, the transmission is only done later if the channel is free. If two stations send data at the same time, collision is detected, they wait for random time and then resend the data.

- **CSMA/CA (Collision Avoidance)** -

  Collision can be avoided through the use of three strategies -

  1. Interface space
  2. Contention window
  3. Acknowledgement

  Uses Request to Send (RTS) and Clear to Send (CTS)
Collision Free Protocols -

5. Basic Bit Map -

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*Frames: 1 3 7 *

8 Contention slots

6. BRAP (Broadcast Recognition/Alternating Priorities) -

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*Frames: 1 3 4 5 6 7 *

7. Multi-level Multi-access (MLMA) - 10 slots (decade)

**FRAME A**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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</thead>
<tbody>
<tr>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

All nodes winnert (most significant bit)

**FRAME B**

| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Node, 61 and 66 remain

**FRAME C**

| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Node 45 and 46 remain

Node with address: 45, 49, 66 and 61

8. Binary Count Updown -

**Binary Time**

- 0 1 2 3
- 0 1 0 1
- 1 0 0 1
- 1 0 1 0

- 0 0 1 0
- 0 1 0 0
- 1 0 0 0
- 1 0 1 0

Result: 1 0 1 0

Station 0010 and 0100 see 1010 and give up
Station 1001 sees 1 and gives up

Station 0010 and 0100 see 1010 and give up

Station 1001 sees 1 and gives up

Node with address: 45, 49, 66 and 61
**Limited Contention Protocols**

9. **Adaptive Tree Walk**

![Diagram of tree walk](image)

If there is collision then the nodes are divided into two equal groups and only one of these groups completes for slot 1.

If one of its members again uses the channel then the next slot is reserved for the other group.

10. **URN (Uniform Resource Name) Protocol**

It is a string of characters used to identify a name of a web resource. E.g., `WWW (World Wide Web)`

11. **Fast Ethernet - CAT5**

Came to replace the nominal rate of 100 Mbit/s. It runs on UTP data or optical fibre cable in a star wired bus topology.

12. **Gigabit Ethernet**

Maximum data rate of 1 gigabit per second. CAT5e or CAT6 cables twisted pair cables are used.

13. **Fibre Distributed Data Interface (FDDI)**

Optical data communication standard, distance up to 200k at a speed of 100 Mbps.

It has dual primary and secondary communication rings. Primary ring works alongside the network.

Secondary ring remains idle and available for backup.

Used for voice and video conferences, online business, real-time video and other multimedia.
### Performance Measurement Metrics

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>Throughput</td>
<td>Mbps</td>
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<tr>
<td></td>
<td>Effective Capacity</td>
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</tr>
<tr>
<td>Responsiveness</td>
<td>Delay</td>
<td>Milliseconds</td>
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<tr>
<td></td>
<td>Round Trip Time</td>
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<td>Queue Size</td>
<td>Packets</td>
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<td>Utilization</td>
<td>Channel Utilization</td>
<td>Percentage of Time Busy</td>
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<td>Packet Loss Rate</td>
<td>Loss Percentage</td>
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<td>Frame Retransmit</td>
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<tr>
<td>Buffer Problem</td>
<td>AP Queue Overflow</td>
<td>Packets Drops</td>
</tr>
<tr>
<td></td>
<td>Fragment Buffer Underflow</td>
<td>Rebuffer Events</td>
</tr>
</tbody>
</table>

**Metrics:** A descriptor used to represent some aspect of a computer network's performance.

### IEEE 802 Standards

```
802.1 (Bridging)
```

```
802.2

802.3  802.4  802.5  802.11

LLC   MAC   Physical

802.11  →  WiFi
```

**Family of Standards for LANs**

802.11  →  WiFi