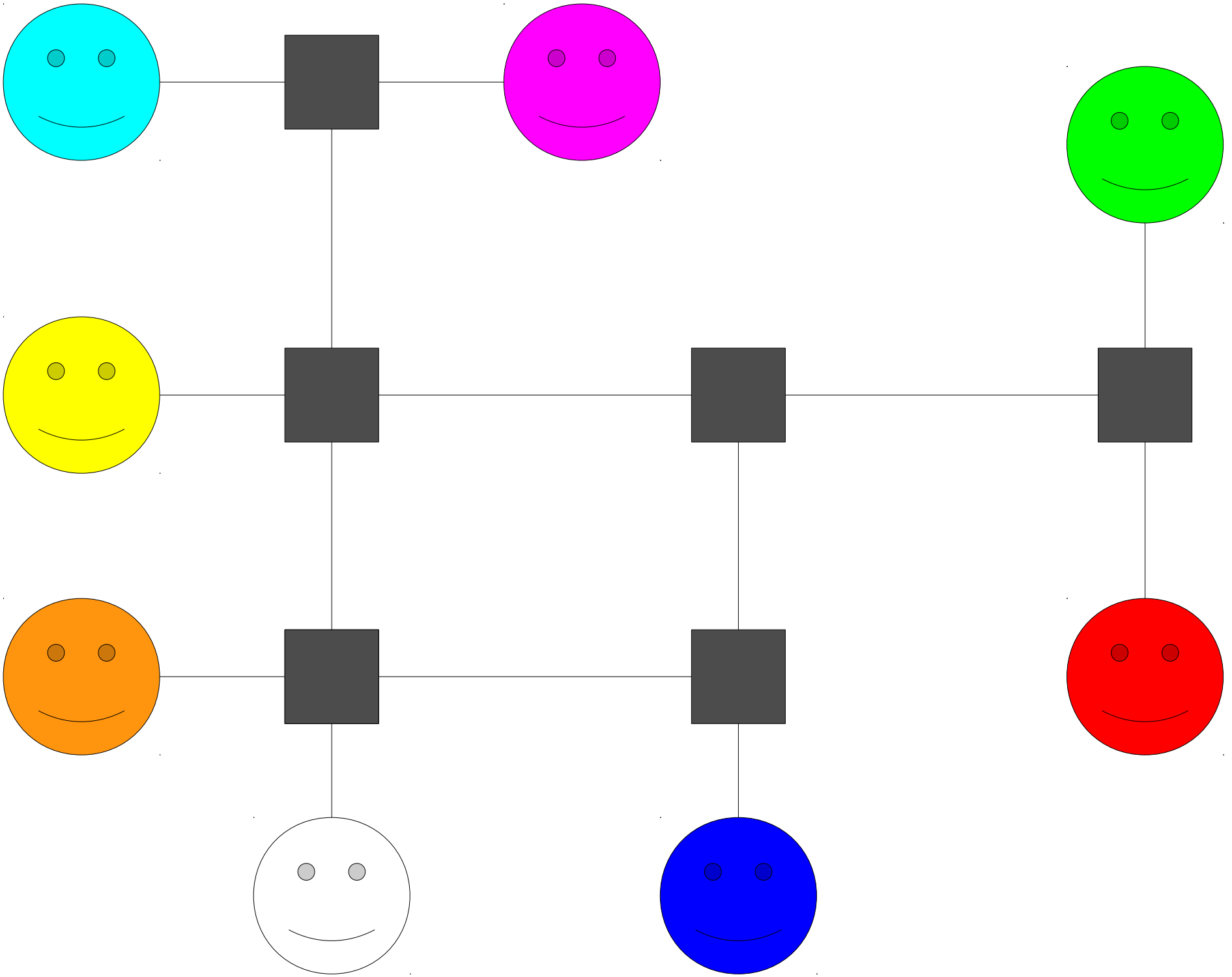
Networking

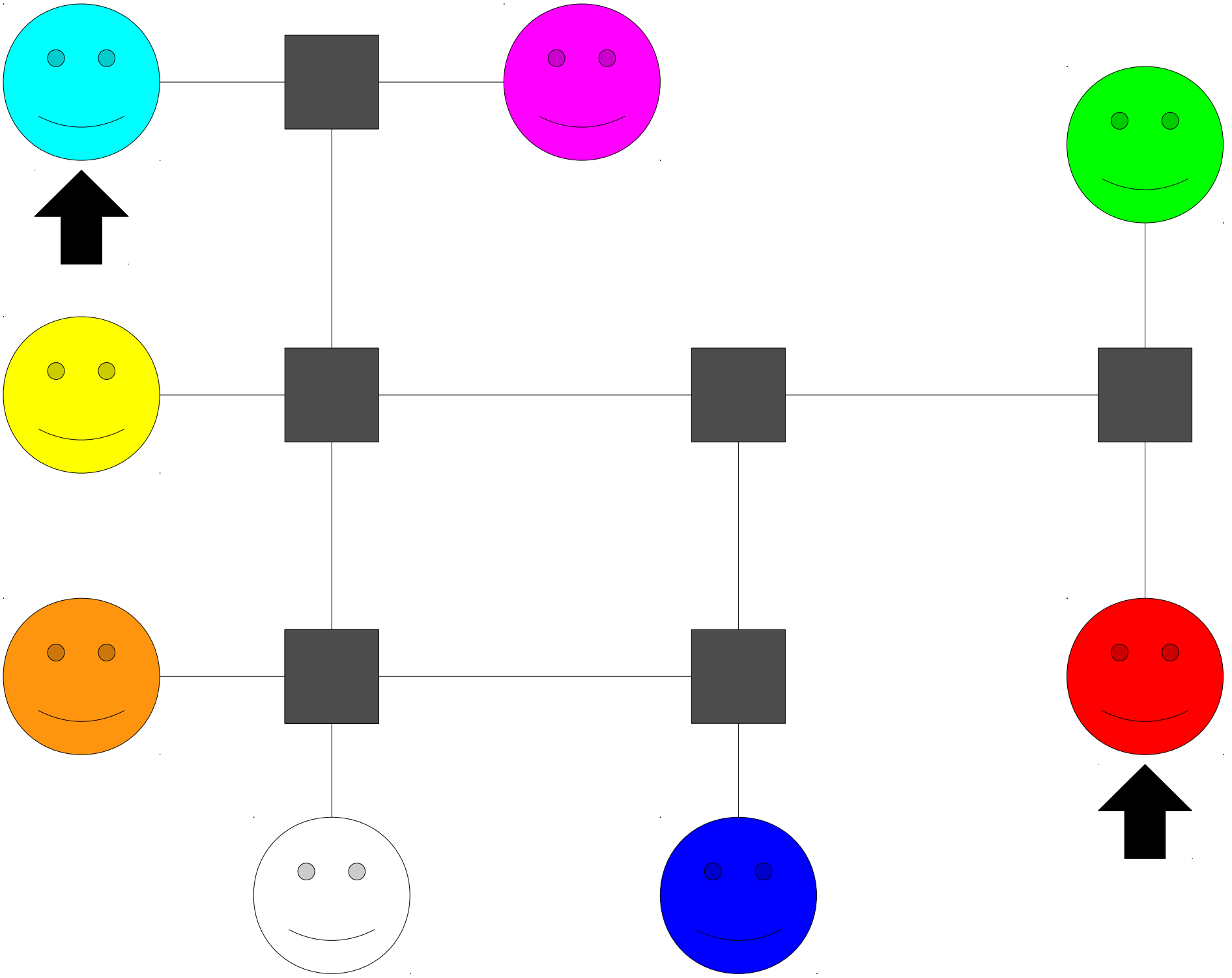
Friday Four Square!
Outside Gates, 4:15PM

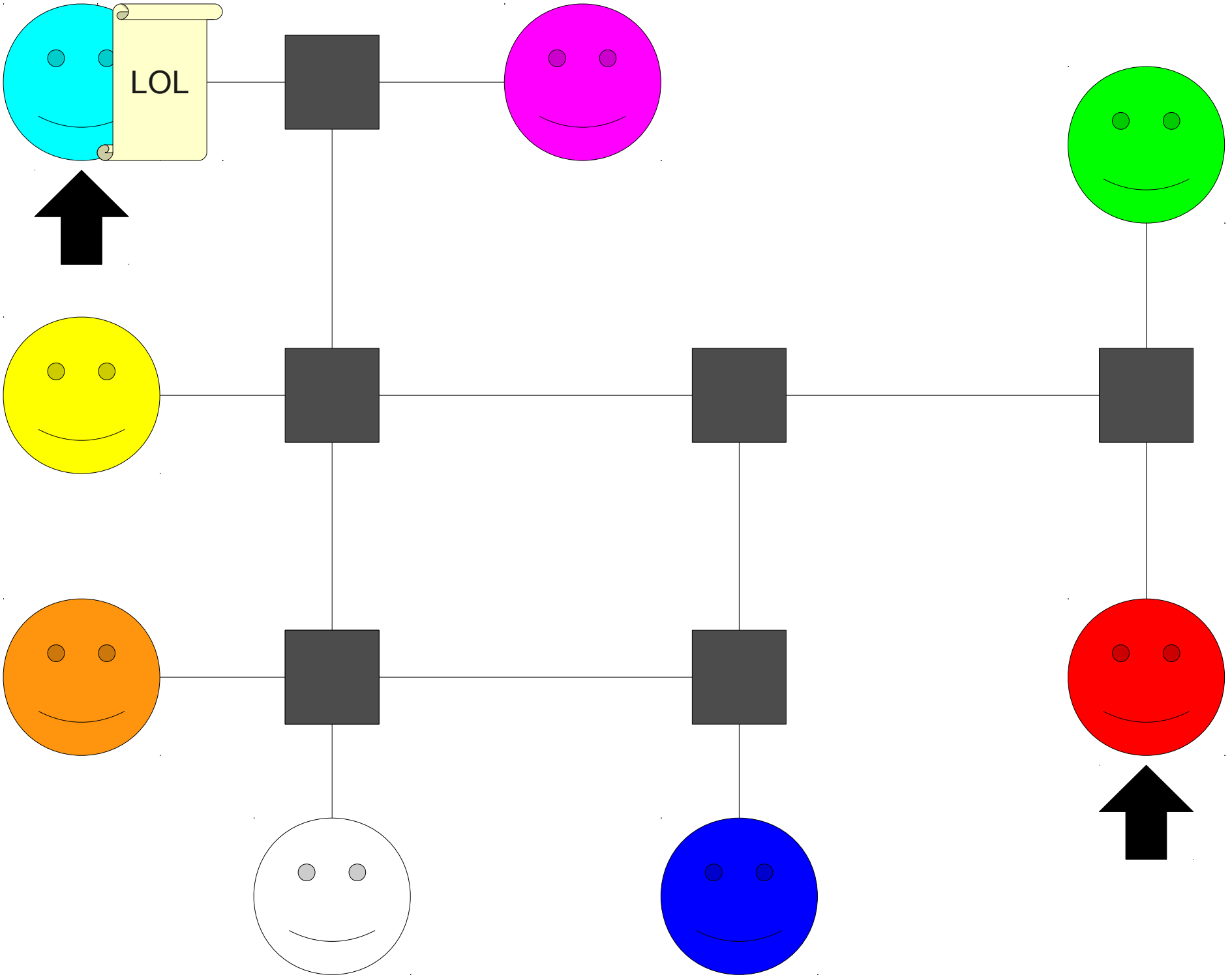
Computer Networks

- Computer networks allow us to get amazing things done.
  - Sharing knowledge (Wikipedia, Khan Academy, etc.)
  - Solving huge problems (folding@home, SETI, etc.)
- Computer networks prevent us from getting amazing things done.
  - Social networks (Facebook, Google+, etc.)
  - Streaming video (Hulu, Netflix, etc.)

How does it all work?



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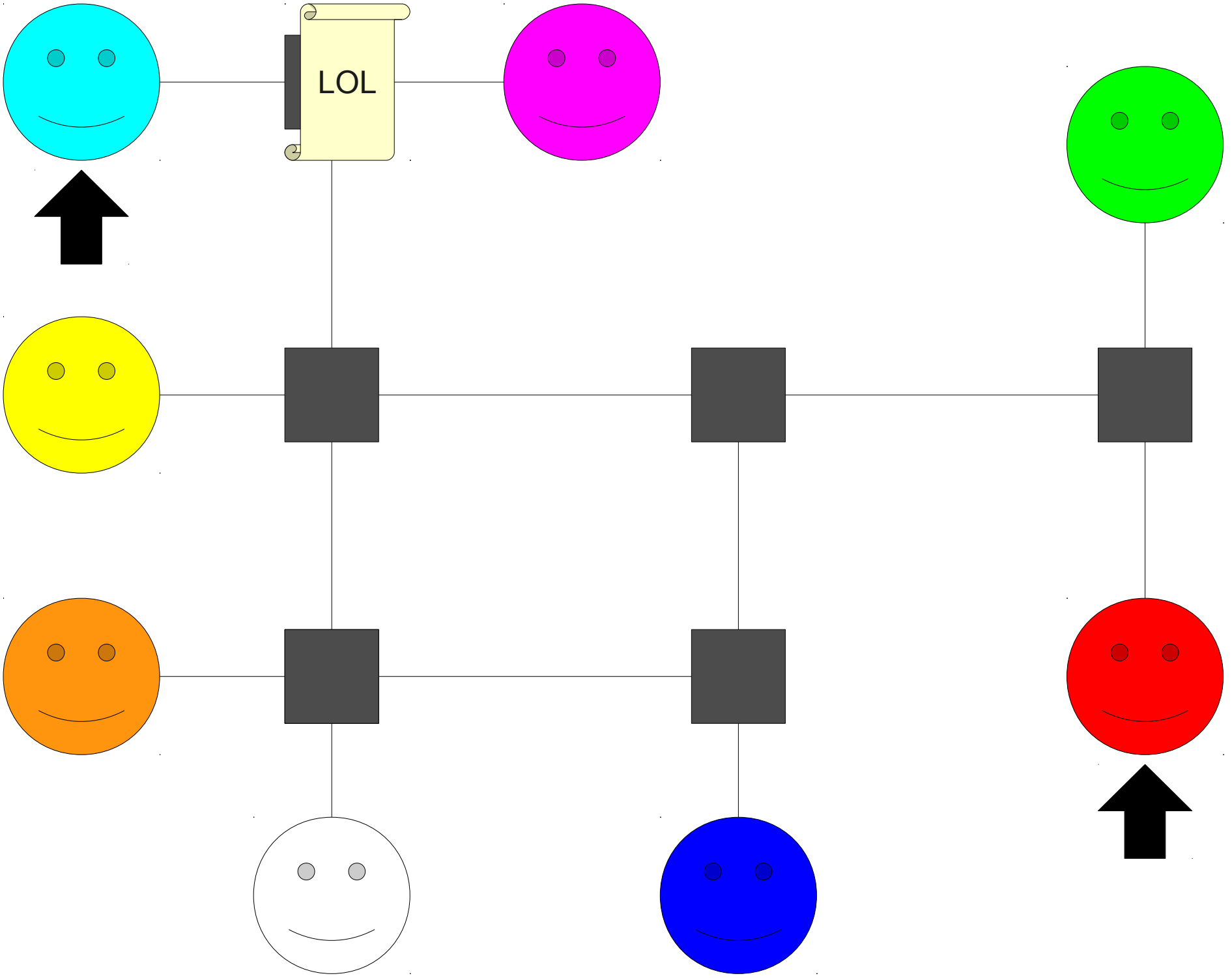
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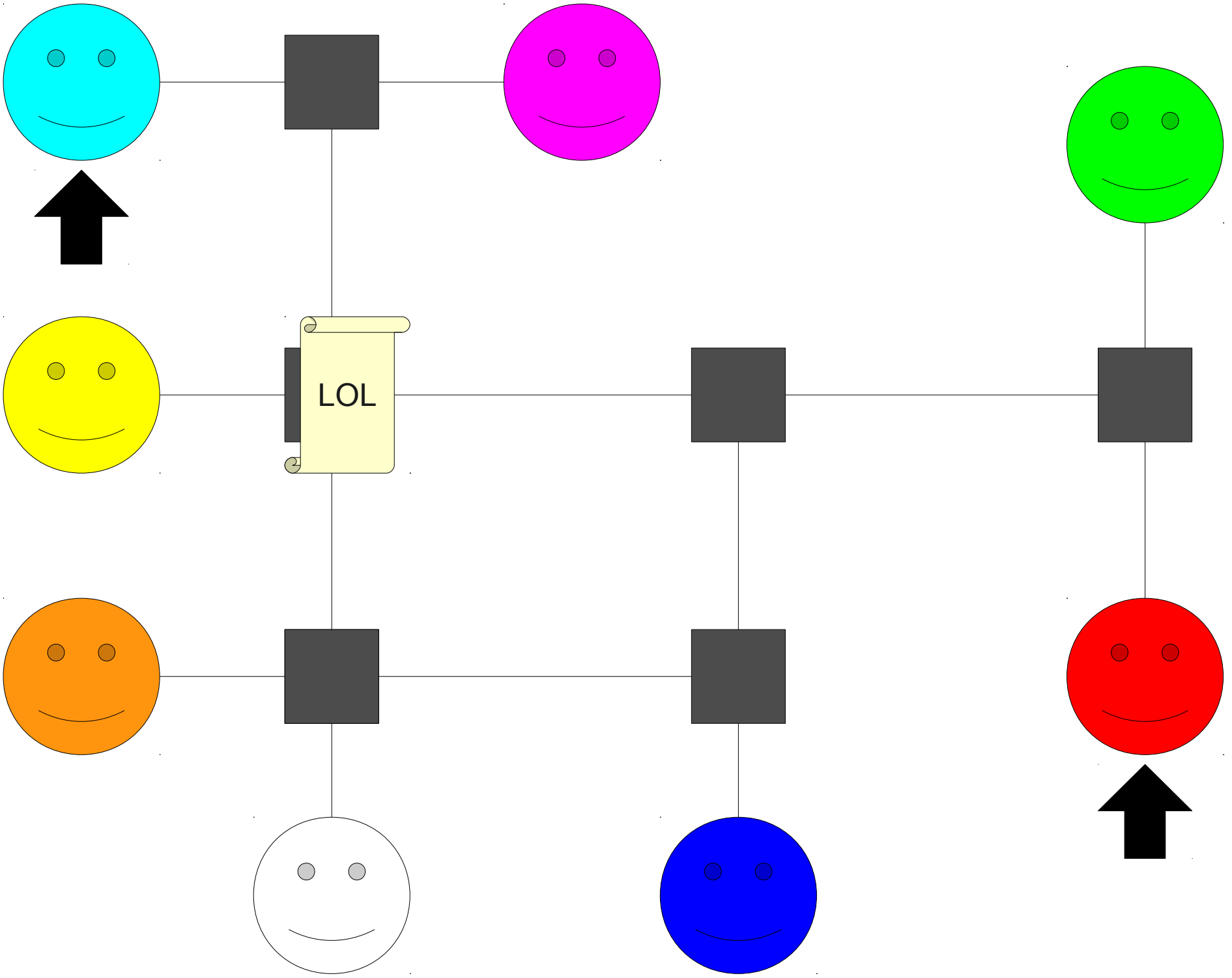
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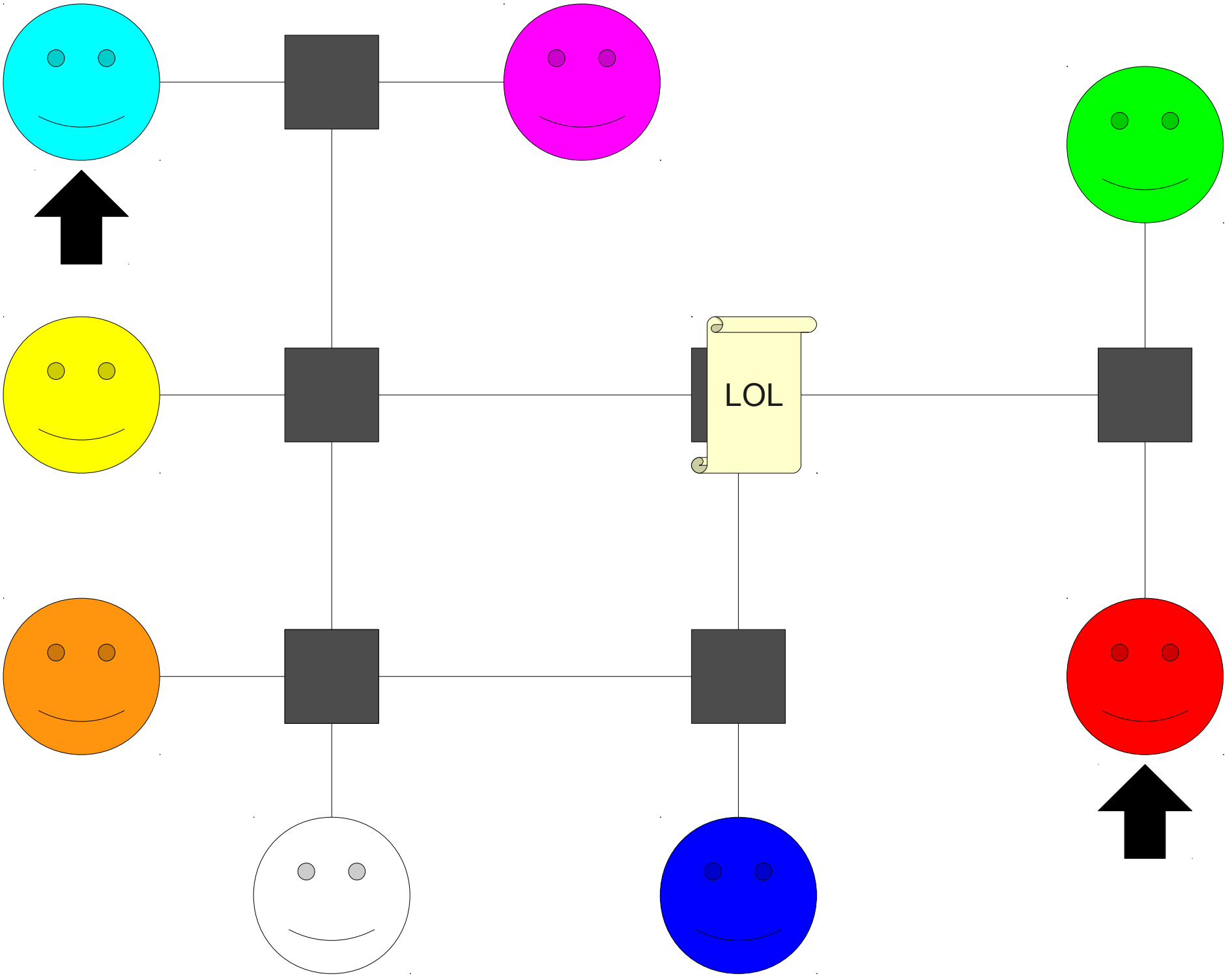
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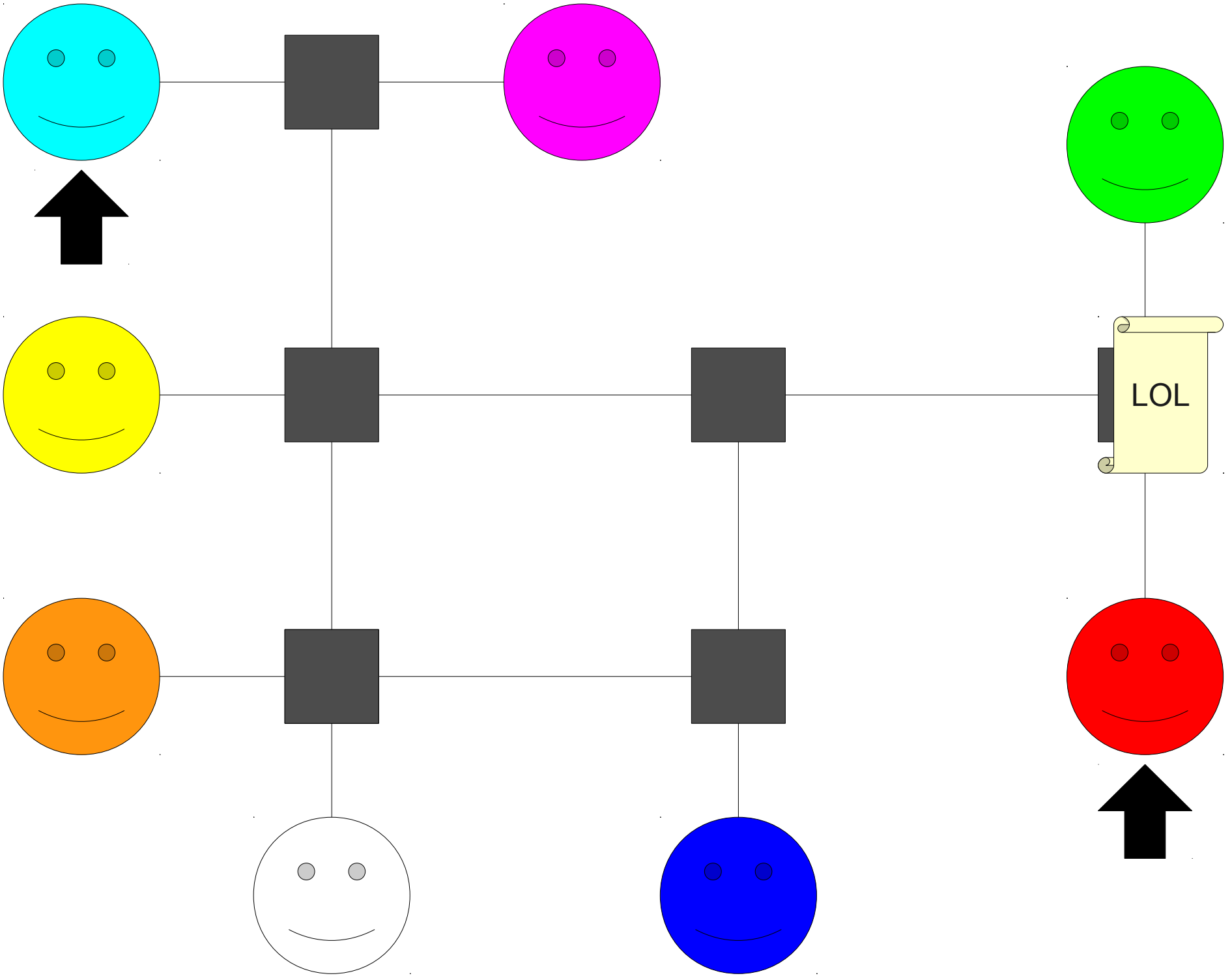
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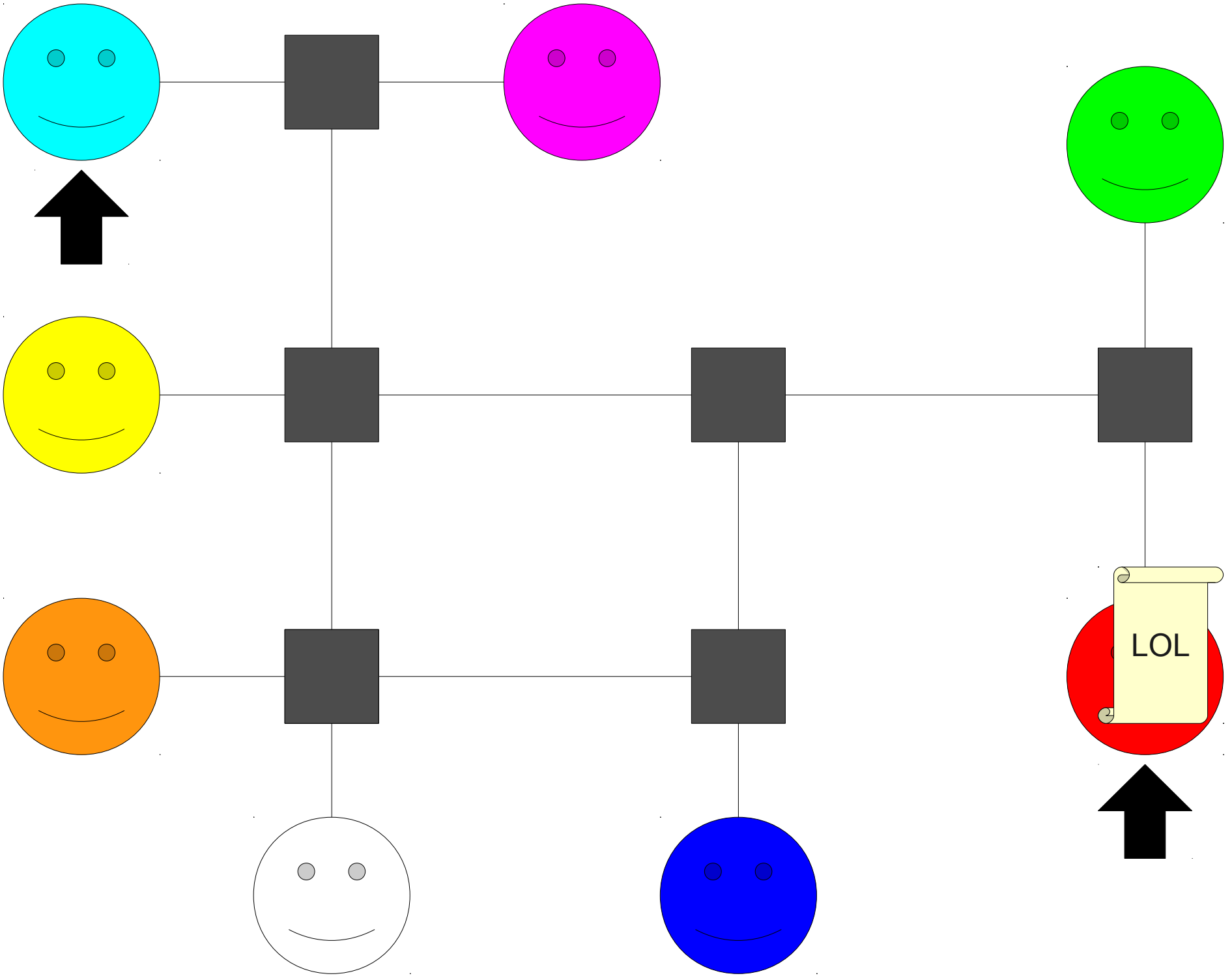
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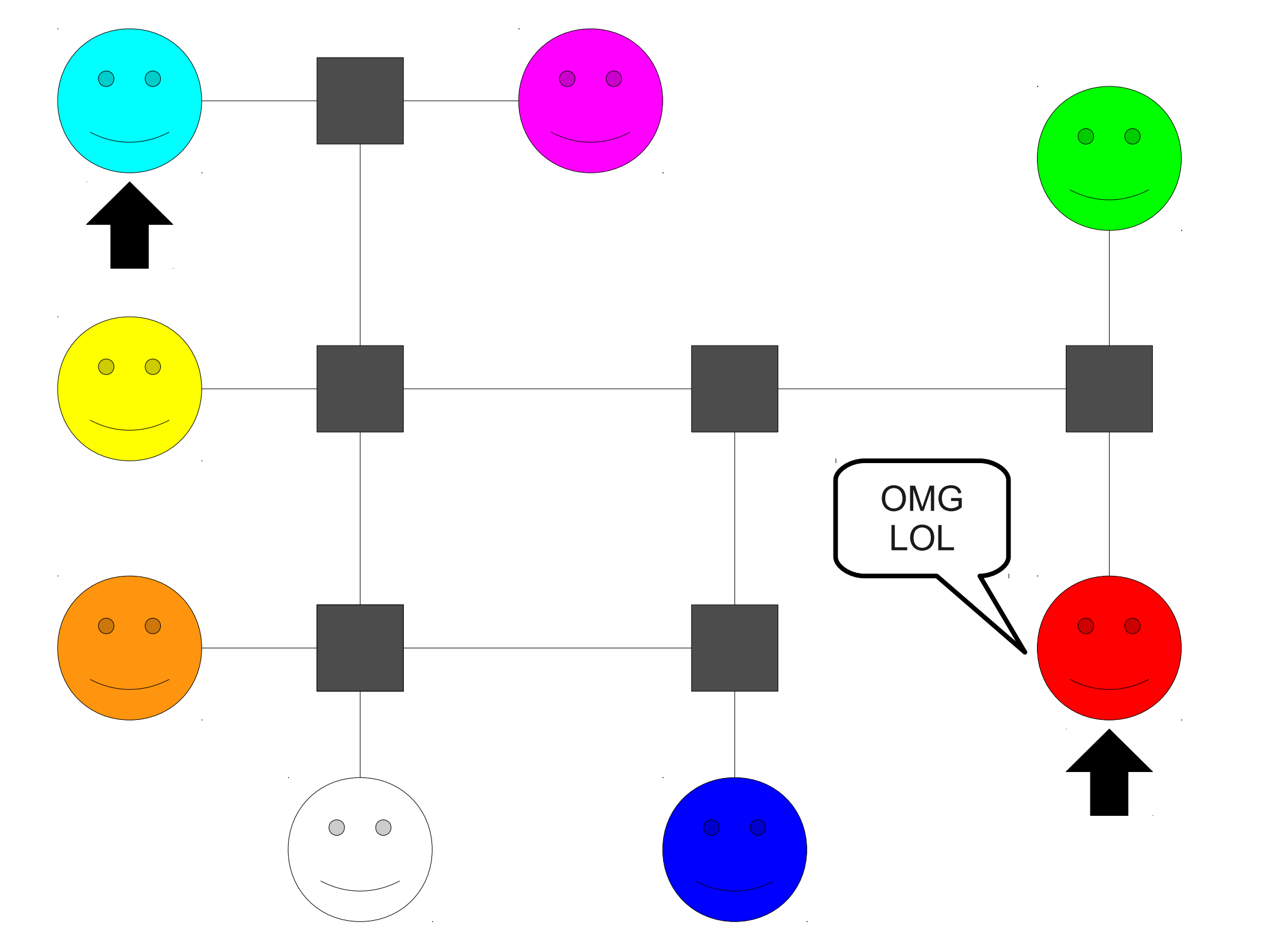
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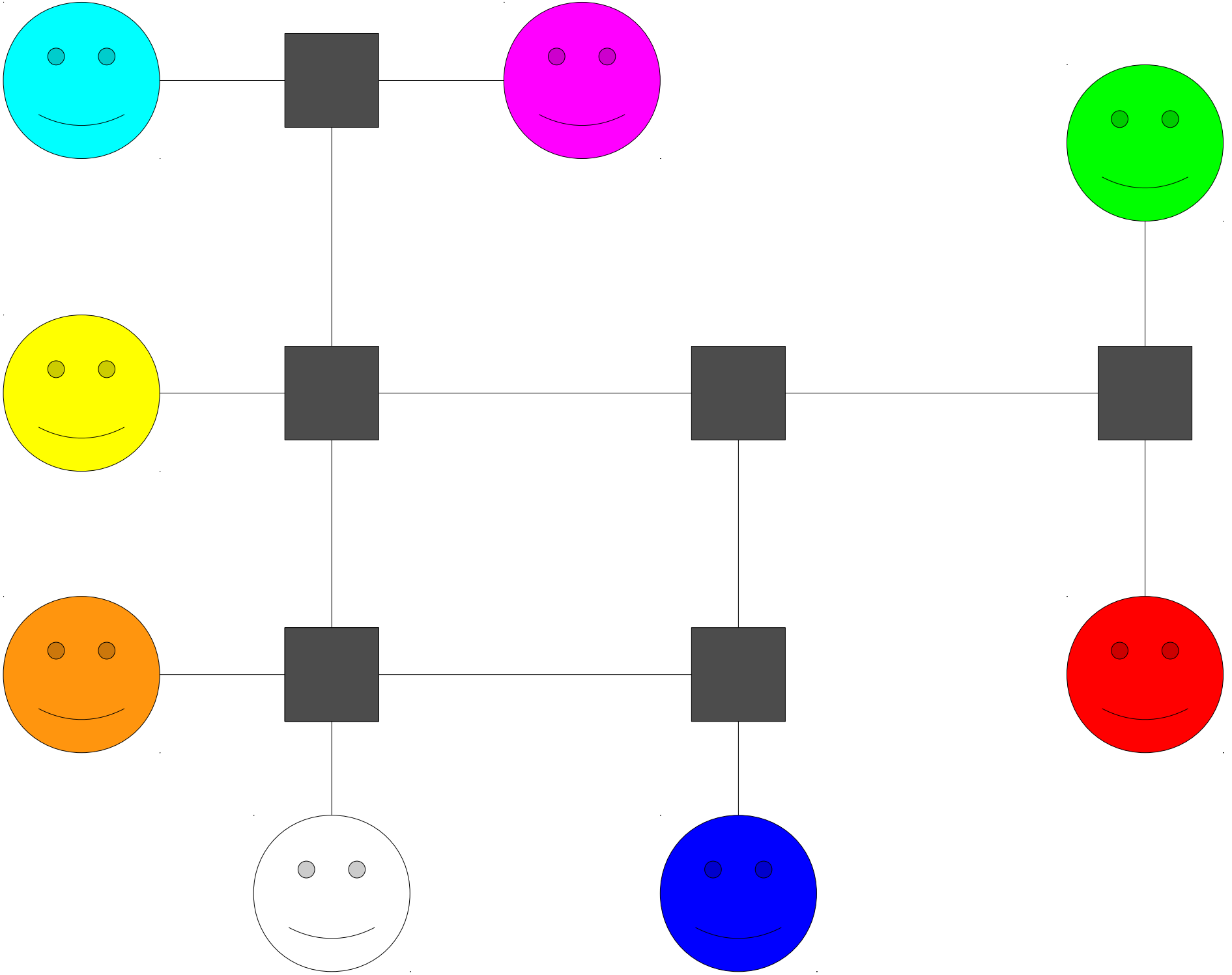
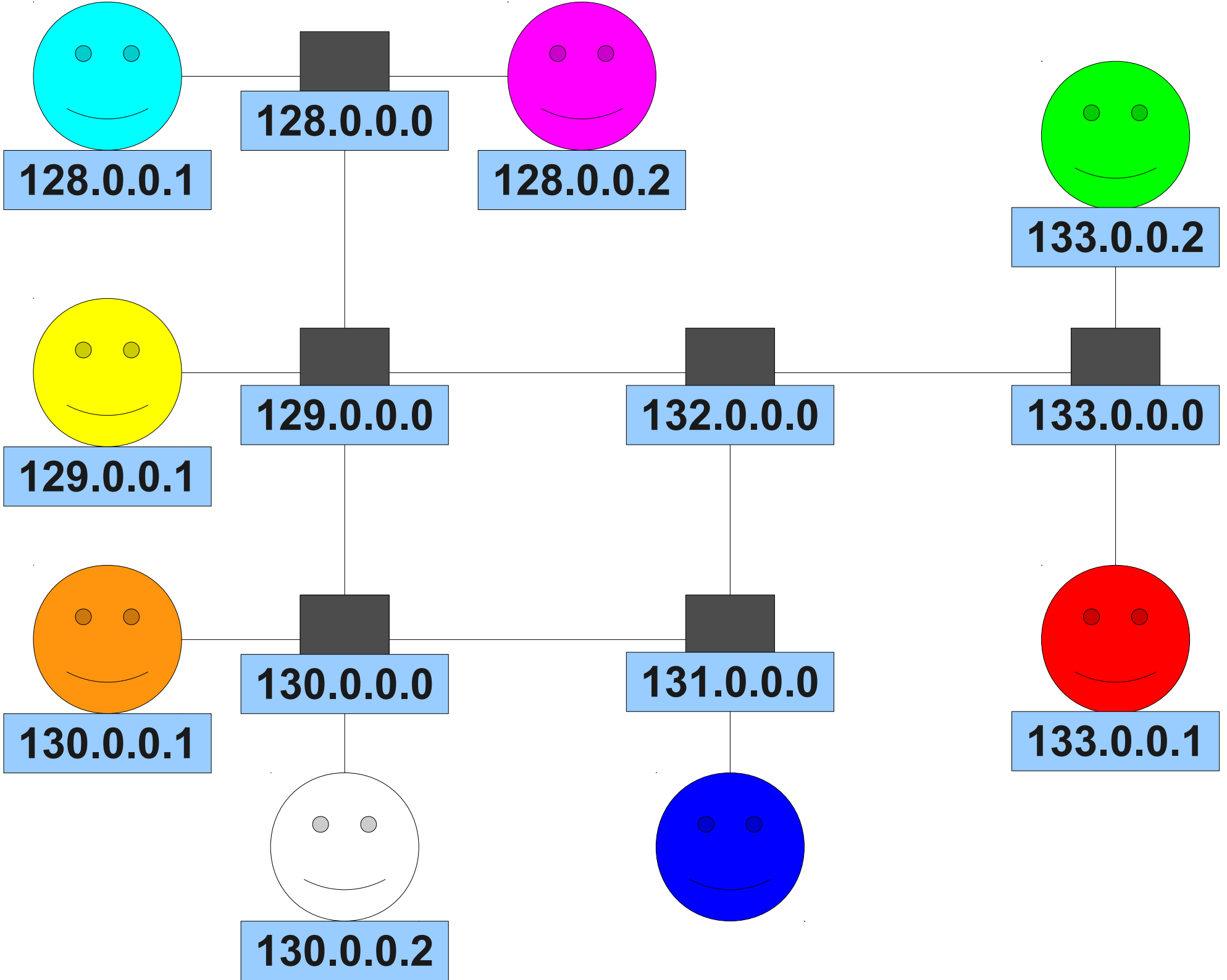
Sending Data

- Data is sent across the Internet in **packets**.
- Each packet contains a message (called the **payload**), along with extra information to help it get to its destination correctly.

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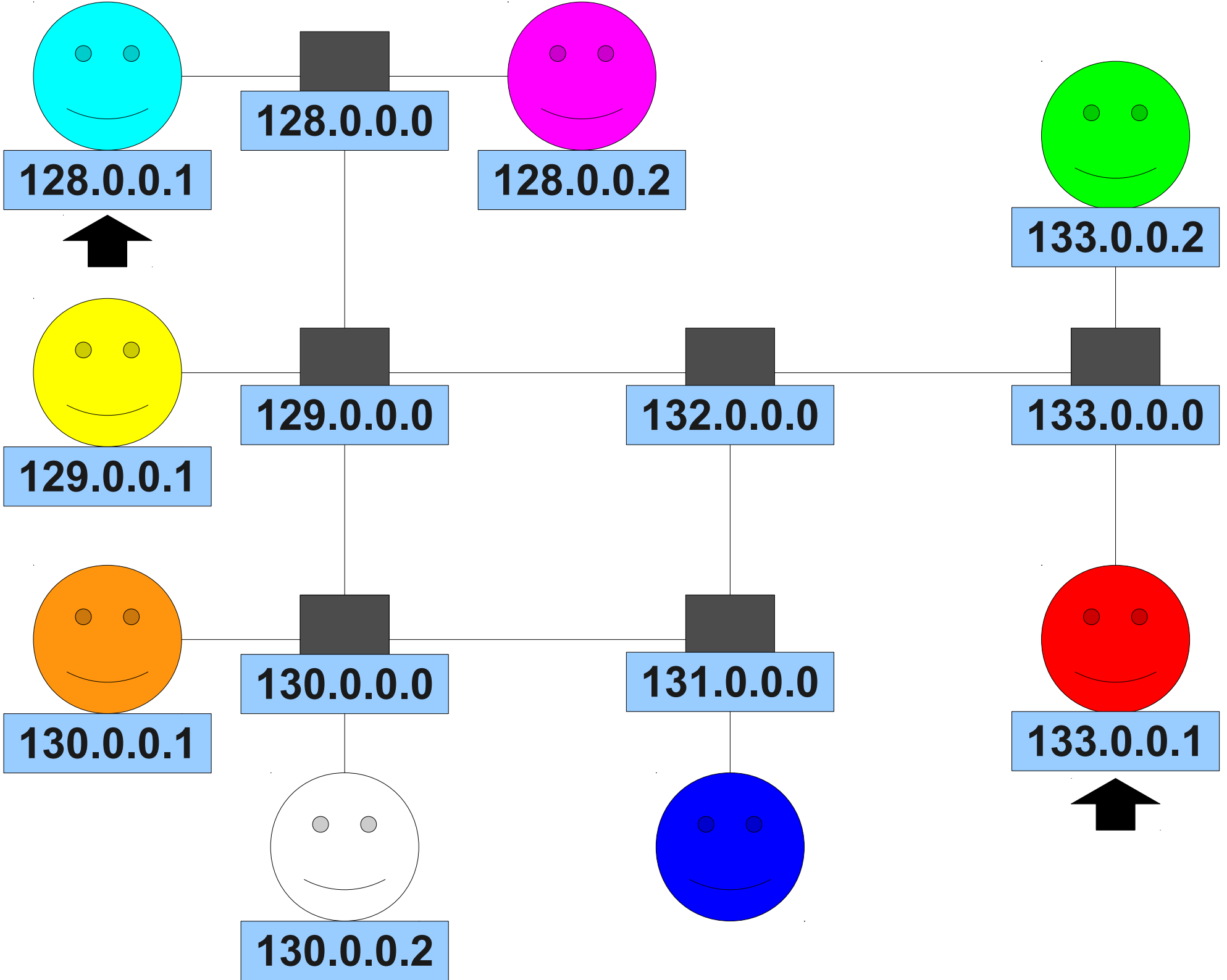
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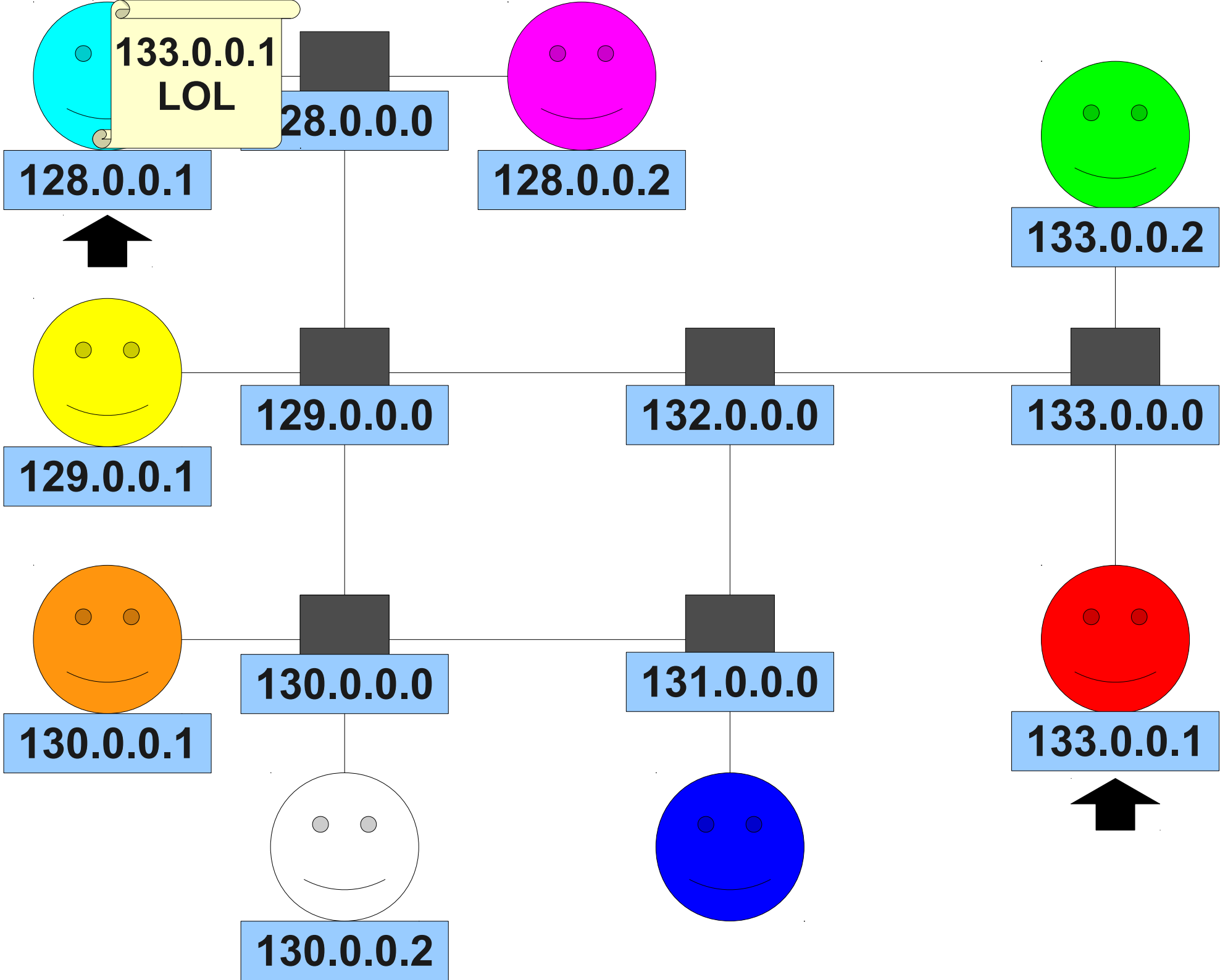
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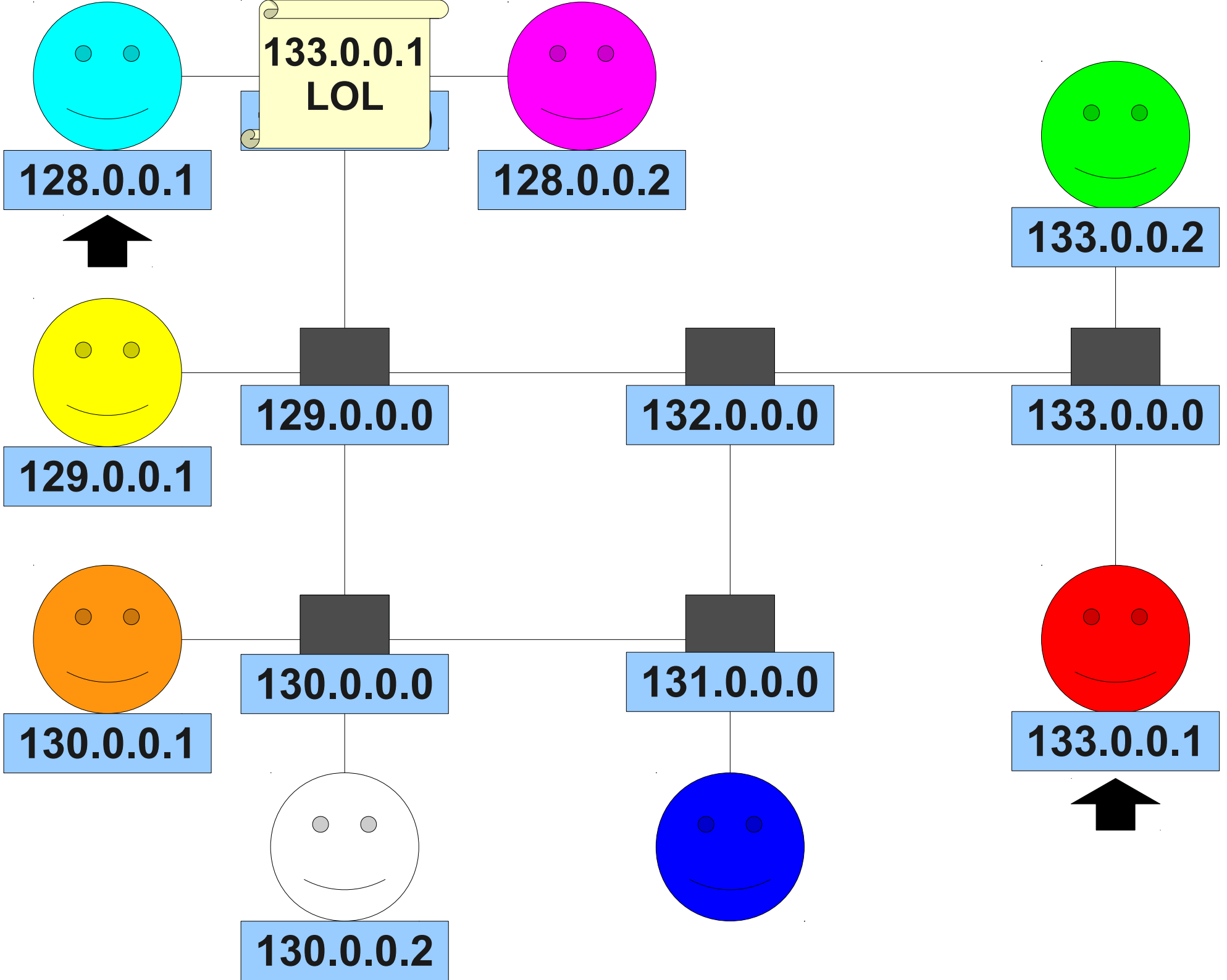
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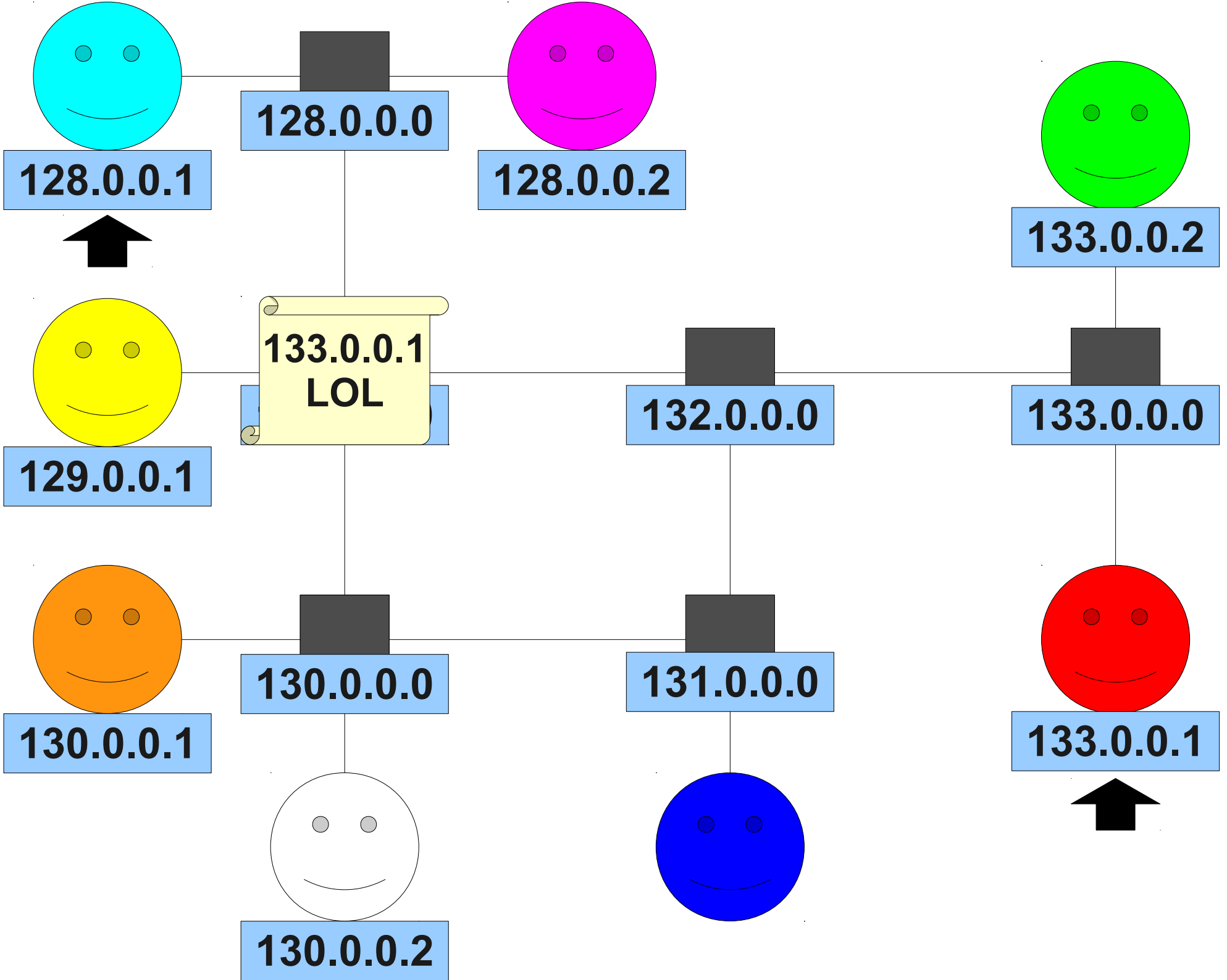
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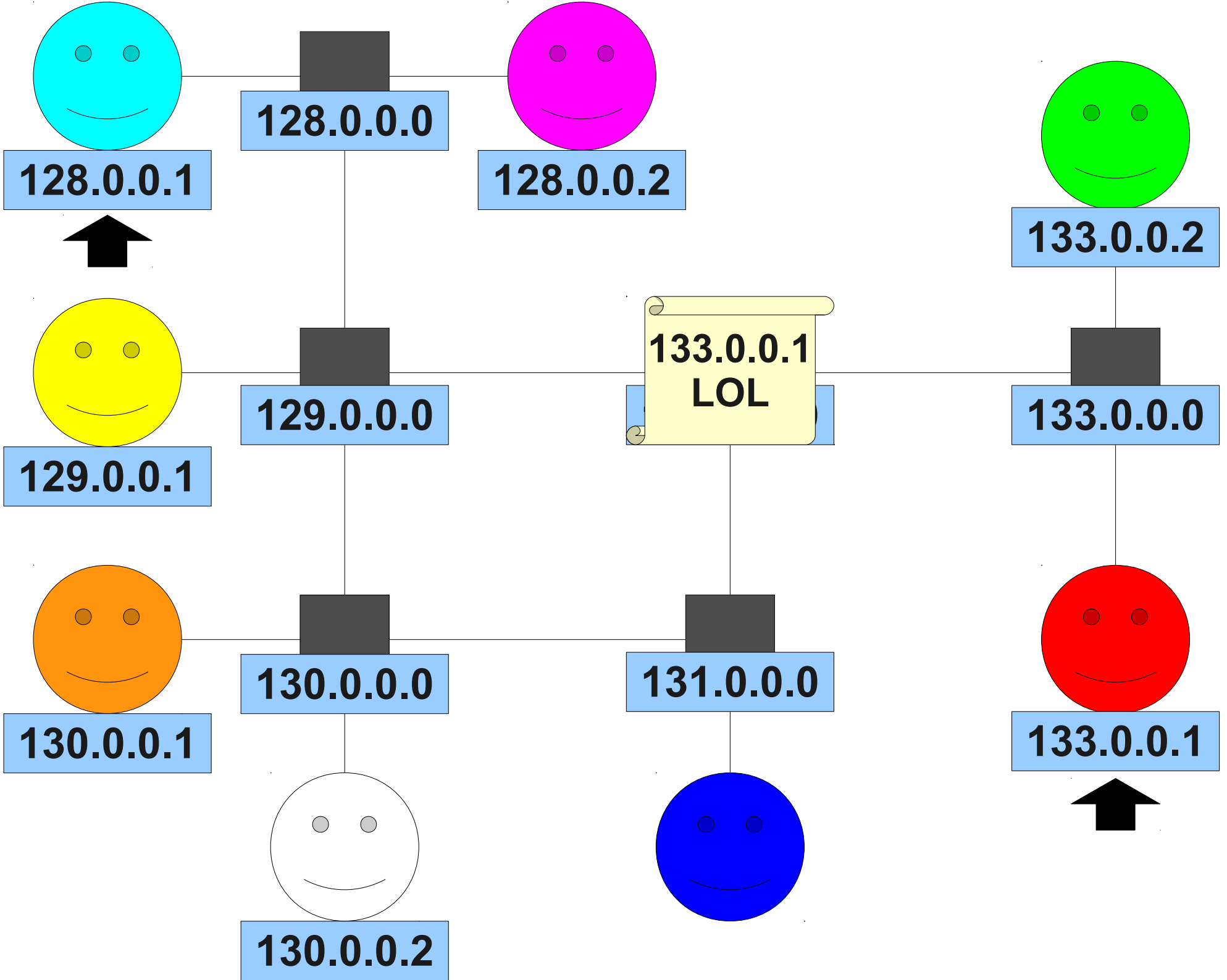
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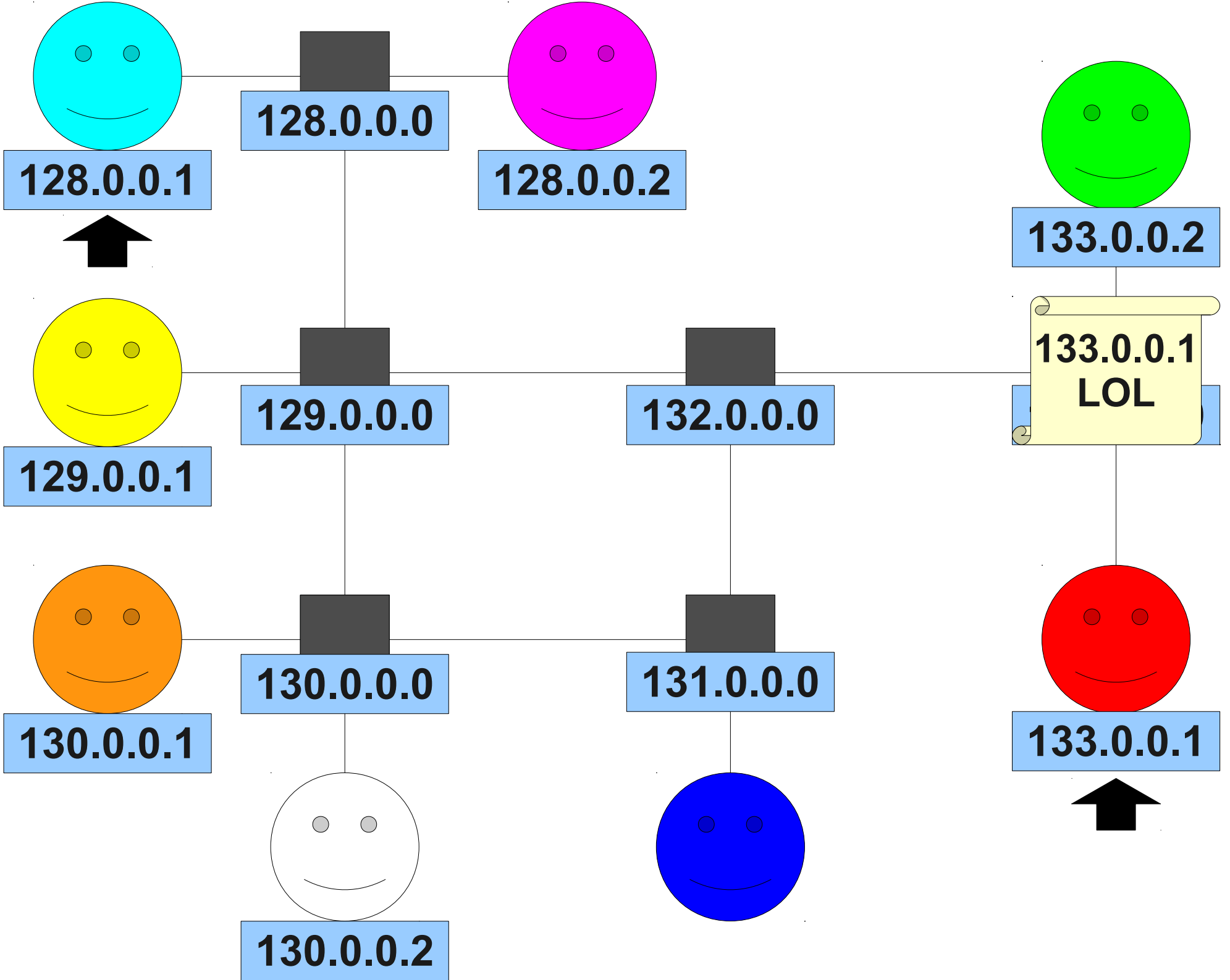
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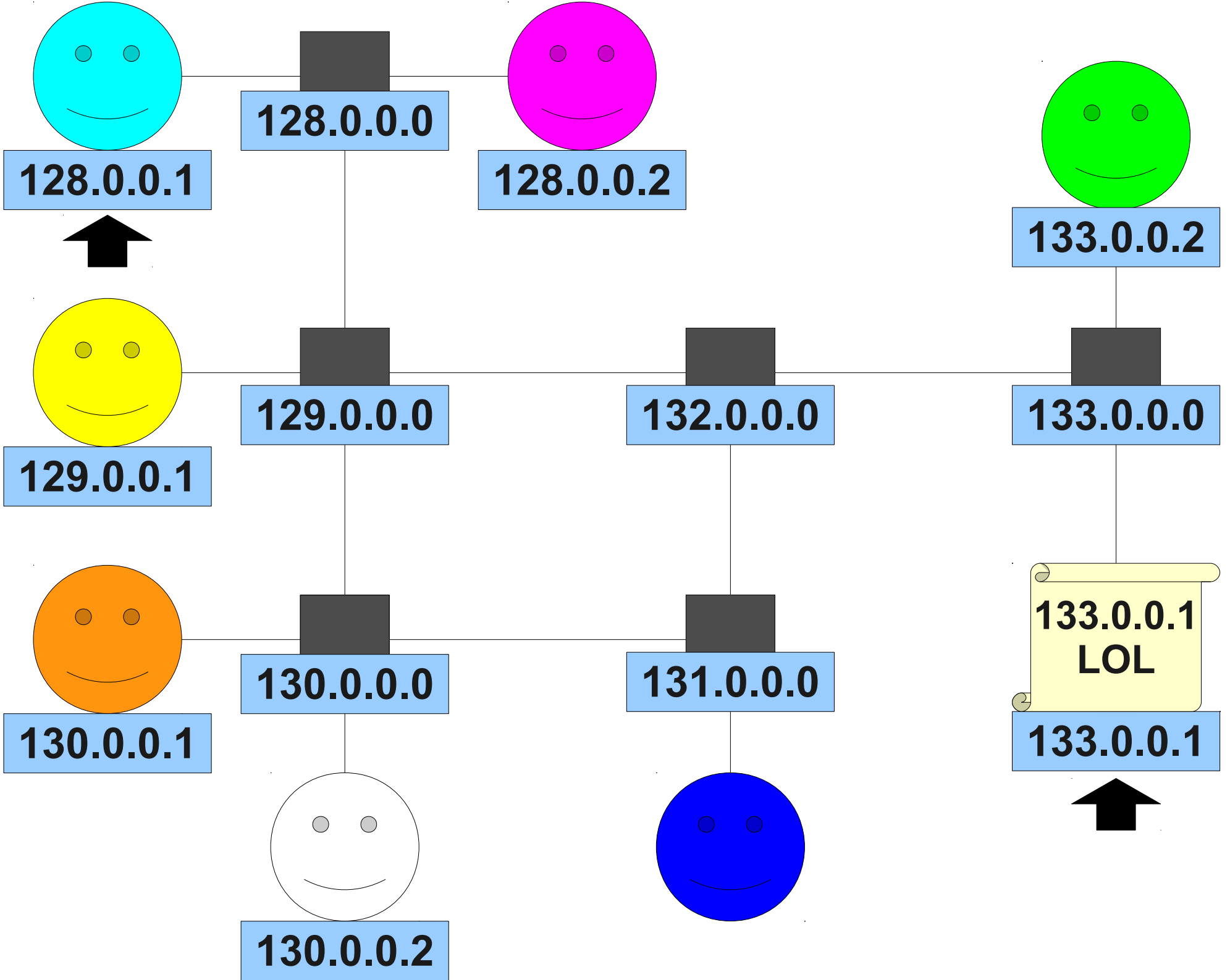
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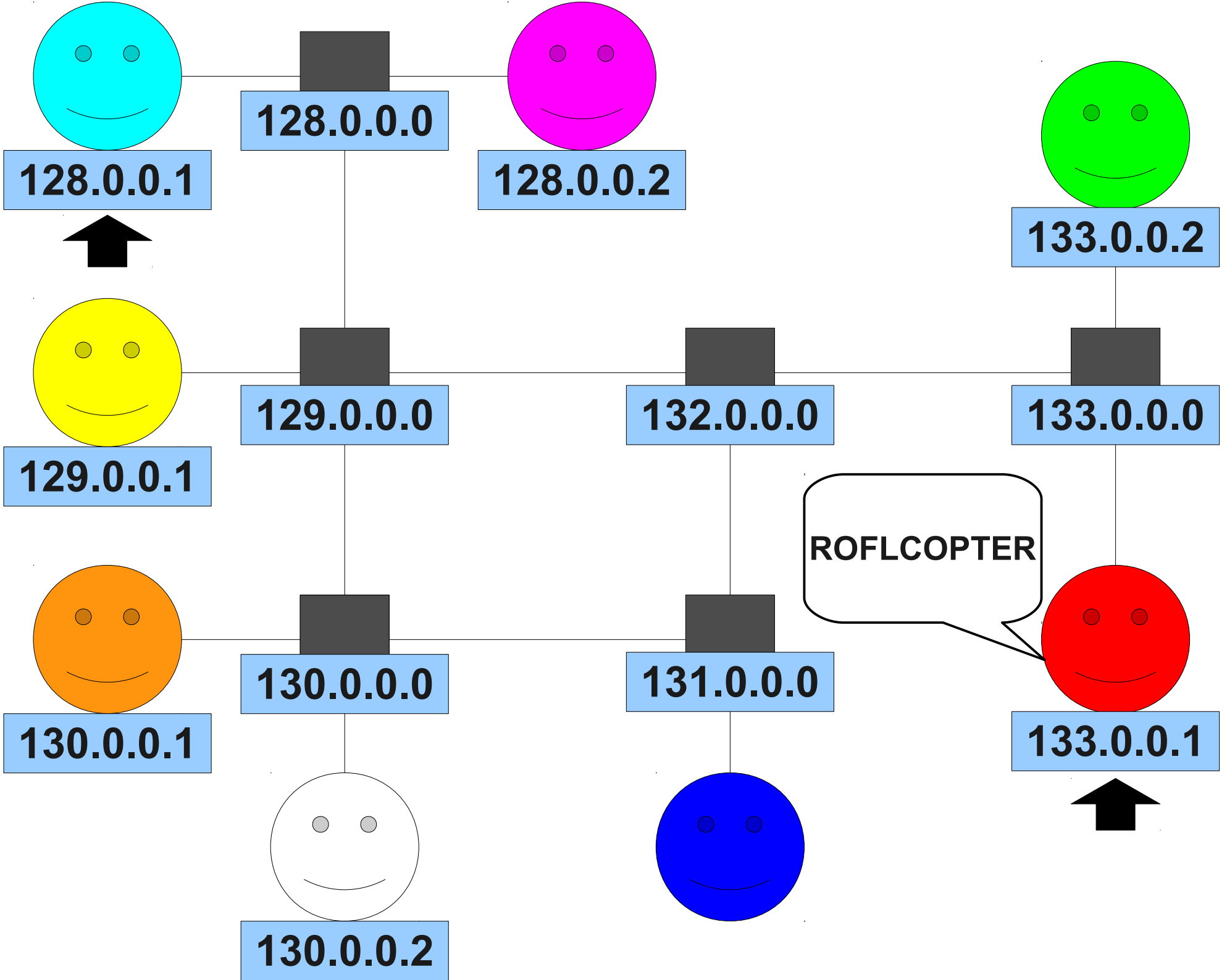
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IP Addresses

- Each computer may have one or more **IP addresses** so that it can receive messages over the Internet.
  - Similar to a phone number.
- There are two types of IP addresses:
  - IPv4: 2^{32} possible addresses (about four billion), and we're rapidly running out!
  - IPv6: 2^{128} possible addresses (about 4×10^{34}), and we're very unlikely to run out in the future.

Hostnames

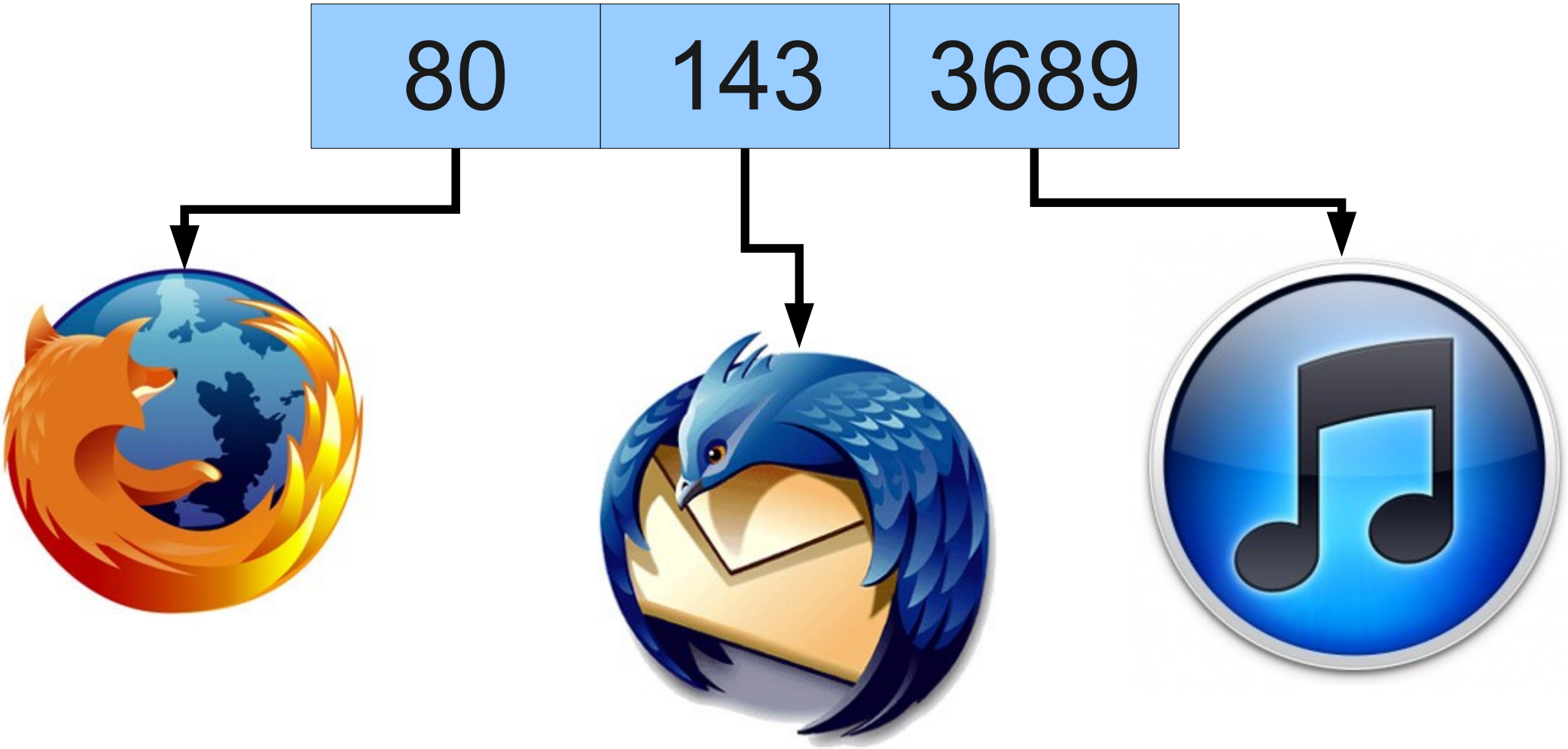
- In order to make it easier to find remote computers, computers can have names associated with them.
  - www.google.com
  - www.stanford.edu
- These names are called **hostnames**.
- A system called the **domain name system** is responsible for converting domain names into IP addresses.
  - Kind of like a huge `Map<String, IPAddress>`

A Small Problem

- At any one time, you could be
  - Surfing the web,
  - Downloading music from iTunes,
  - Checking your email,
  - Chatting on IM,
  - etc.
- You might have packets from many different machines all arriving at once.
- How does the computer know how to send each message to the right program?

Ports

- Every packet is labeled with a **port number** that lets the destination computer know how to process the message.
- Different applications listen in on different ports:
  - Sending mail (SMTP): Port 25
  - Browsing the web (HTTP): Port 80
  - Checking email (IMAP): Port 143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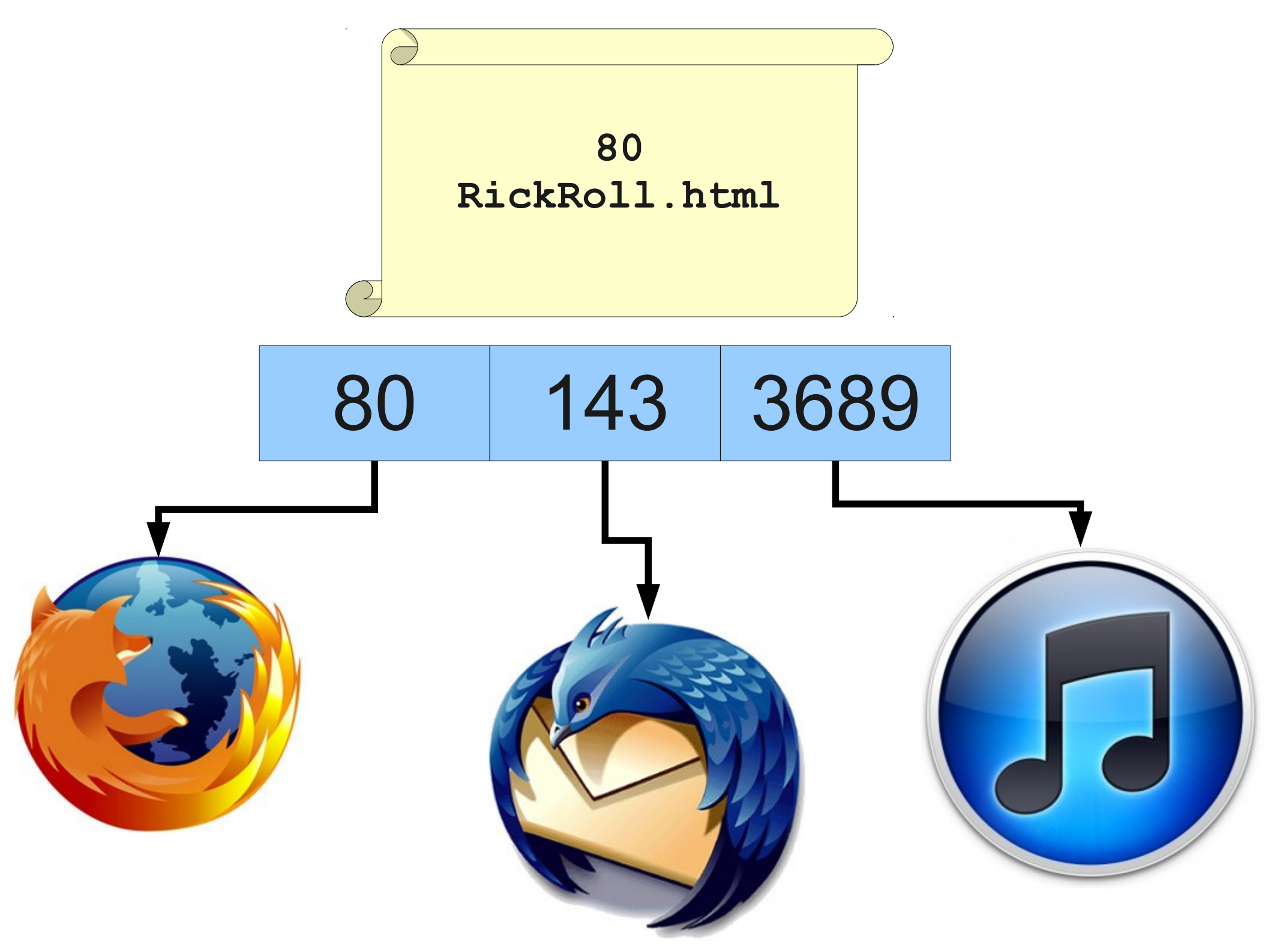
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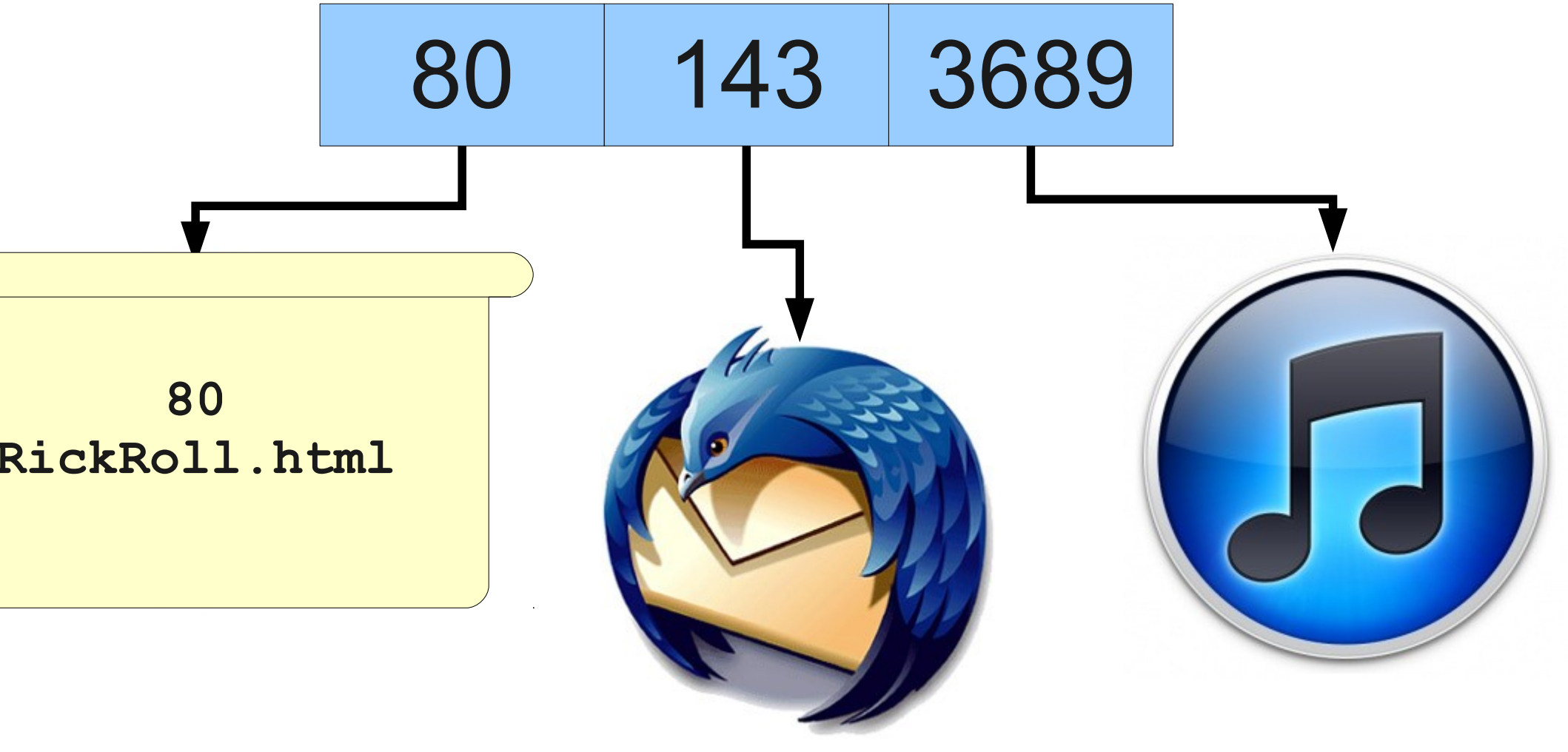
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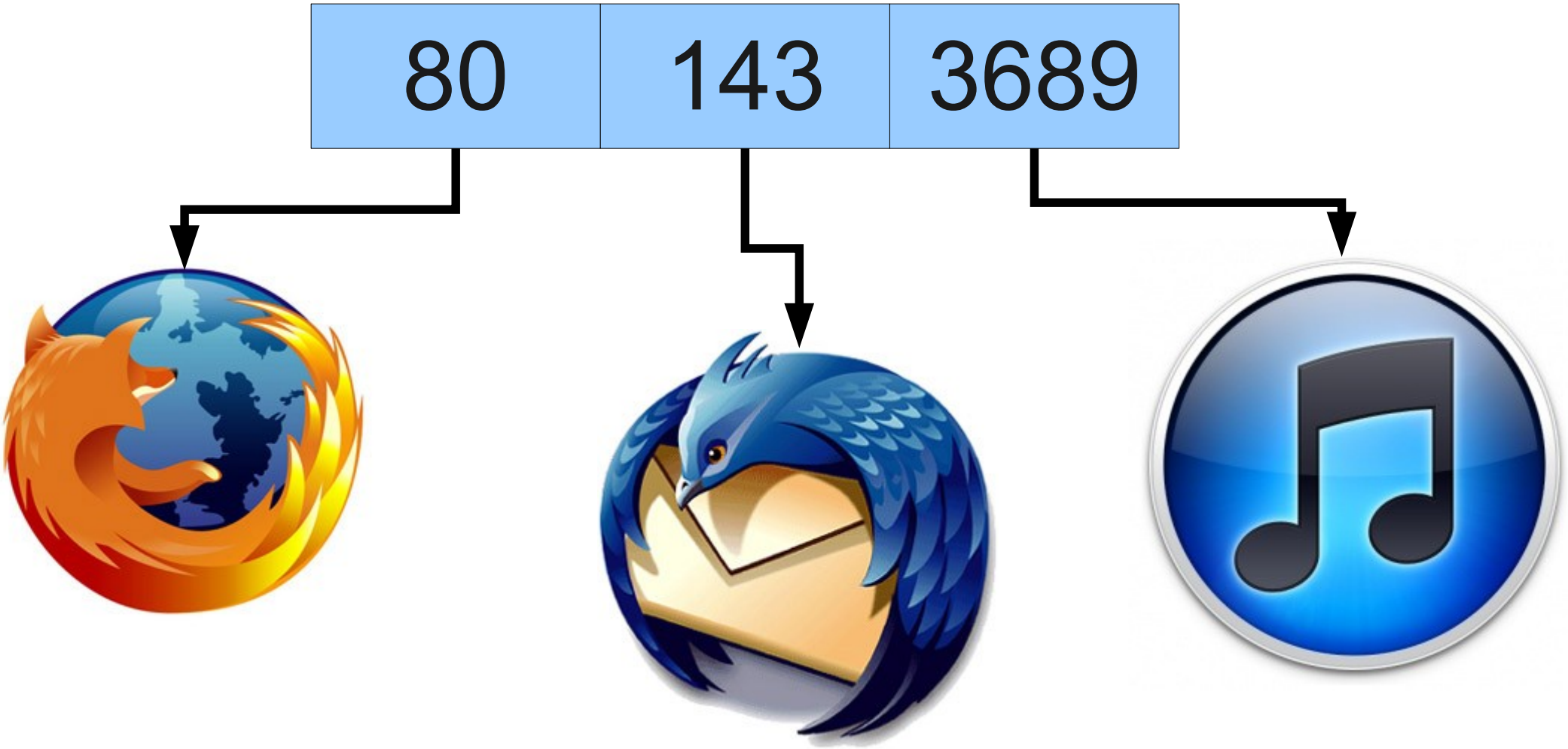
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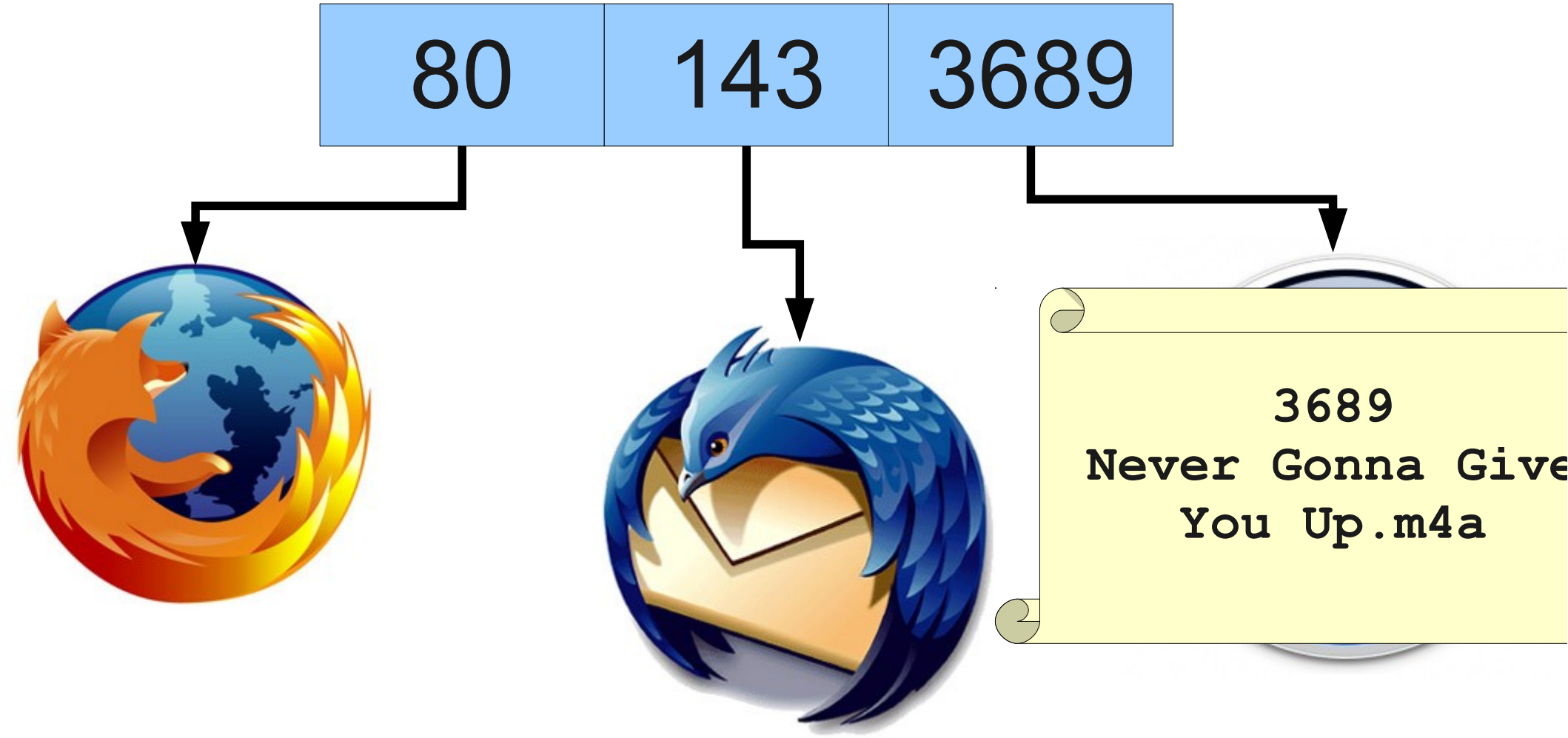
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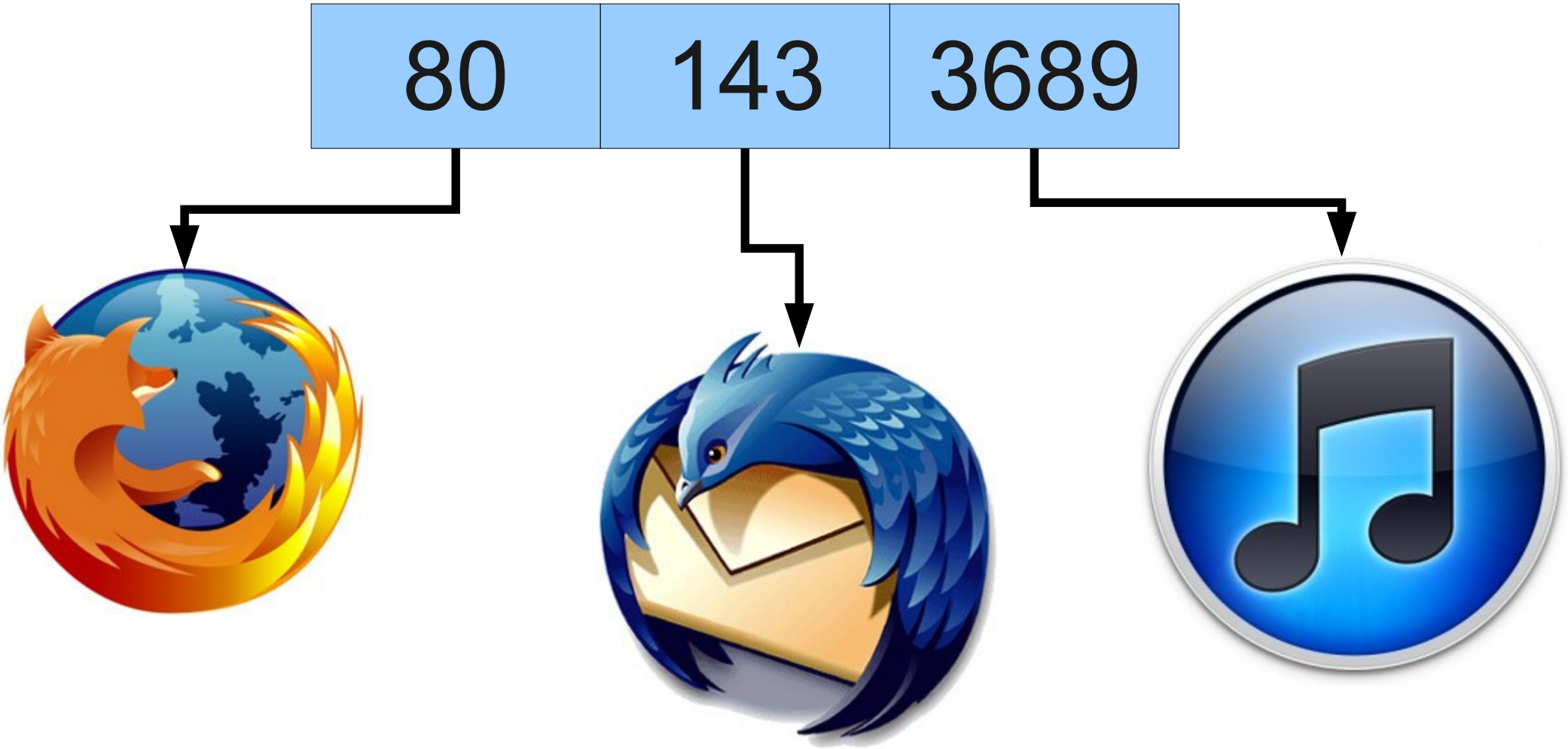
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Sockets

- A **socket** is a combination of an IP address (destination computer) and port number (what program should read the message).
- All the information necessary to ensure that a message gets to the right program on the right computer.
- To set up a connection to a remote computer, you need to create a socket connection to that computer.

Application Protocols

- Now that we can get computers talking to one another, how do they communicate information in a meaningful way?
- An **application protocol** is a set of rules computers can follow to communicate over a network.
- Each computer follows the rules of the protocol to share information.

An Example: **HTTP**

Networking in Java

- To connect to a remote machine:
  - Create a socket connection to the machine by giving a combination of the host name and the port.
  - Create a **`BufferedReader`** to read messages coming from the other computer.
  - Create a **`PrintWriter`** to send messages to the other computer.
  - Send and receive messages as you see fit!

Client/Server Architecture

- A **server** is a program that waits for incoming connections.
  - Typically, has some data or service that it can provide.
- A **client** is a program that initiates a connection to a server.
  - Typically, wants to use that data or service.
  - The program we just wrote was a client that connected to a remote web server.

Acting as a Server

- A program can act as a server as follows:
  - Create a **`ServerSocket`** on a given port and wait for an incoming connection.
  - Obtain a **`Socket`** that lets you communicate with the machine that has connected.
  - Proceed as before.

A Simple Chat Program