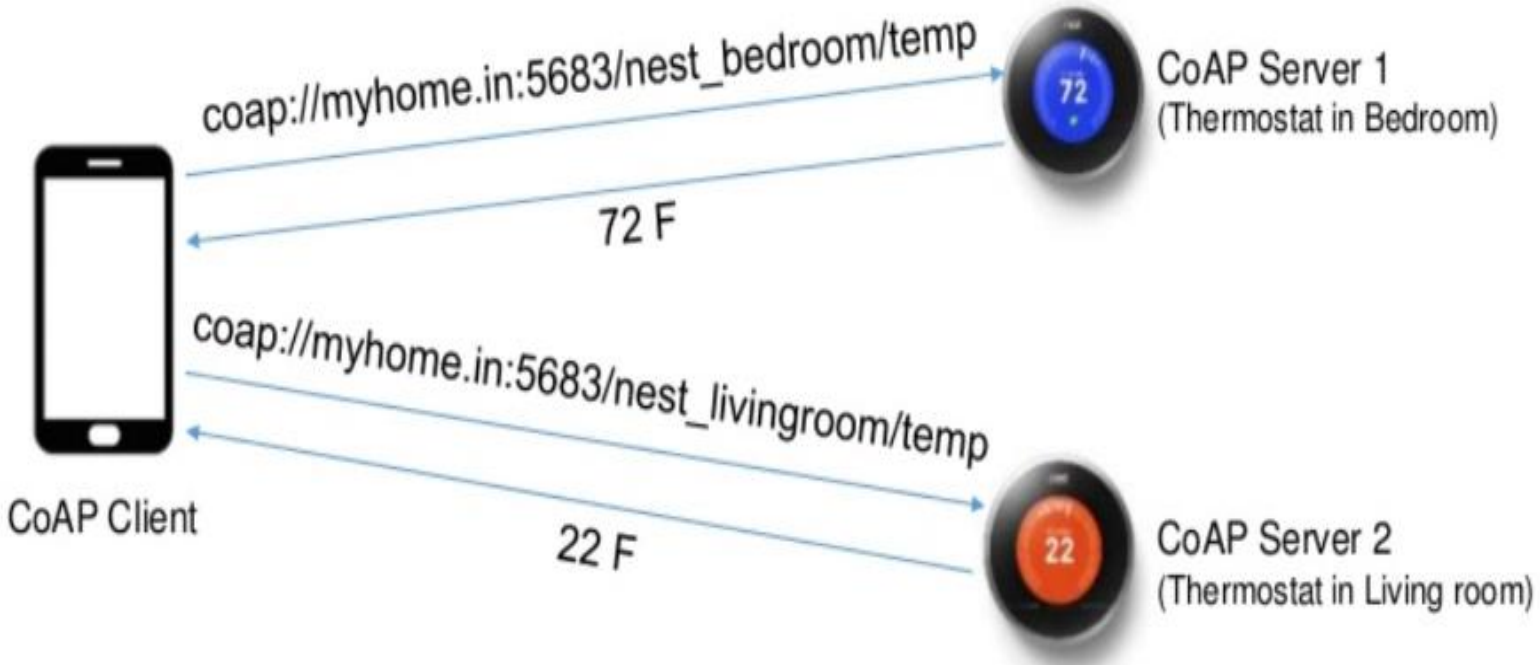
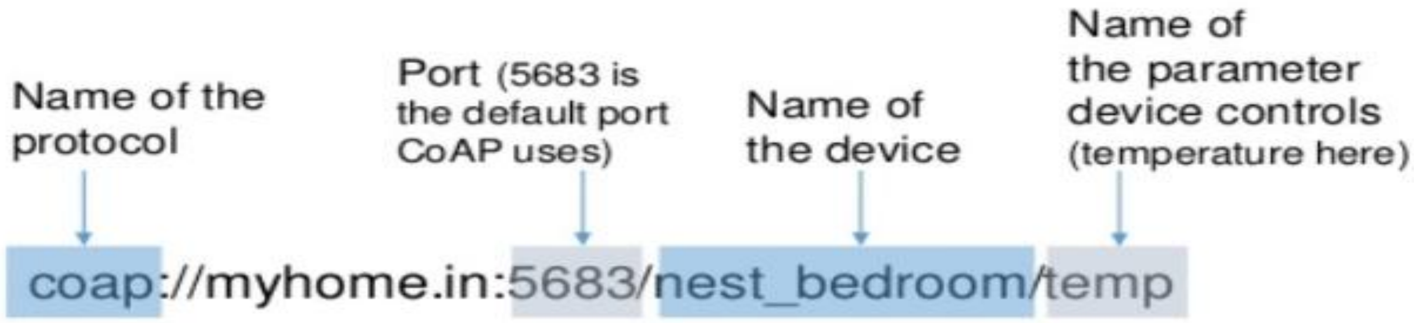
# Constrained Application Protocol (CoAP):

- The **Constrained Application Protocol (CoAP)** is a specialized web transfer protocol for use with constrained nodes and constrained (e.g., low-power, lossy) networks.
- The **nodes** often have 8-bit microcontrollers with small amounts of ROM and RAM, while constrained networks such as IPv6 over Low-Power Wireless Personal Area **Networks** (6LoWPANs) often have high packet error rates and a typical throughput of 10s of kbit/s.
- CoAP provides **a request/response interaction model** between application endpoints, supports built-in discovery of services and resources, and includes key concepts of the Web such as URIs and Internet media types


coap://myhome.in:5683/nest_bedroom/temp
72 F
coap://myhome.in:5683/nest_livingroom/temp
22 F
CoAP Client
CoAP Server 1
(Thermostat in Bedroom)
CoAP Server 2
(Thermostat in Living room)
72
22

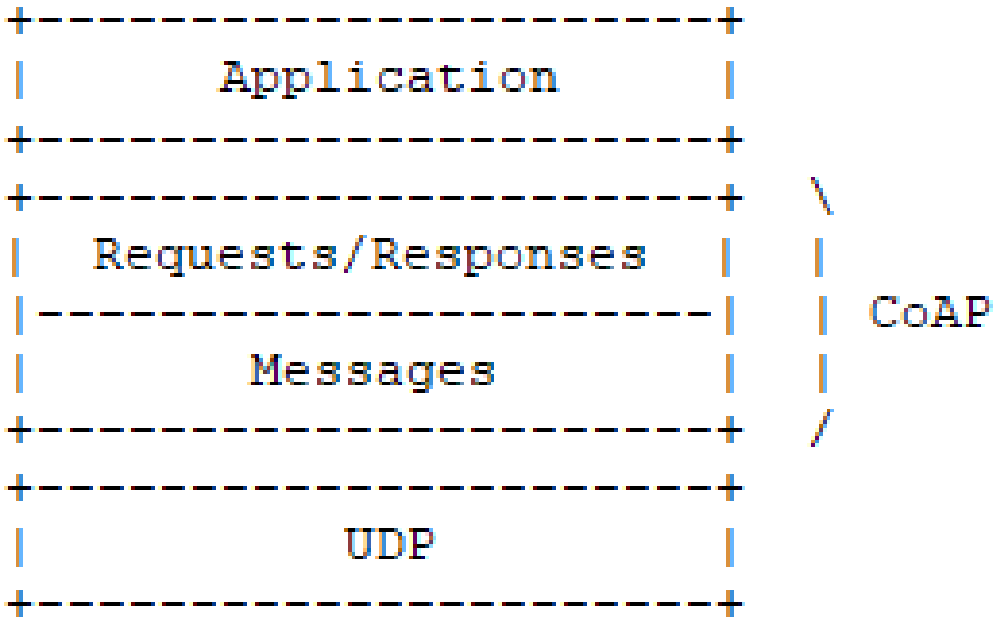

Name of the protocol
Port (5683 is the default port CoAP uses)
Name of the device
Name of the parameter device controls (temperature here)
coap://myhome.in:5683/nest_bedroom/temp

# CoAP Vs HTTP

- A CoAP request is equivalent to that of HTTP and is sent by a client to **request** an action (using a Method Code) on a resource (identified by a URI) on a server.
- The server then sends a **response** with a Response Code; this response may include a resource representation
- Unlike HTTP, CoAP deals with these interchanges **asynchronously** over a datagram-oriented transport such as **UDP instead of TCP.**UDP handshaking is lighter and easier to implement on microcontrollers.
- CoAP header is only **4 bytes**.
- CoAP can also use UDP's broadcast and multicast features. CoAP communication is using connectionless datagrams. Because datagrams are used, SMS and other packet-based protocols may be used**.**

- CoAP defines four types of messages:
  - Confirmable
  - Non-confirmable
  - Acknowledgement
  - Reset.
- **Method Codes and Response Codes** included in some of these messages make them carry requests or responses.

- One could think of **CoAP logically as using a two-layer approach, a CoAP messaging layer used to deal with UDP and the asynchronous nature of the interactions, and the request/response interactions using Method and Response Codes** (see following Figure).



## Messaging Model

- CoAP uses **a short fixed-length binary header (4 bytes)** that may be followed by **compact binary options** and **a payload**.
- This message format is shared by requests and responses.
- Each message contains a **Message ID** usedto detect duplicates and for optional reliability.

# CON and ACK

- Reliability is provided by marking a message as **Confirmable** (CON).
- A Confirmable message is retransmitted using a default timeout and **exponential back-off between retransmissions**, **until** the recipient sends an **Acknowledgement message** (ACK) with the same Message ID (in this example, 0x7d34) from the corresponding endpoint;

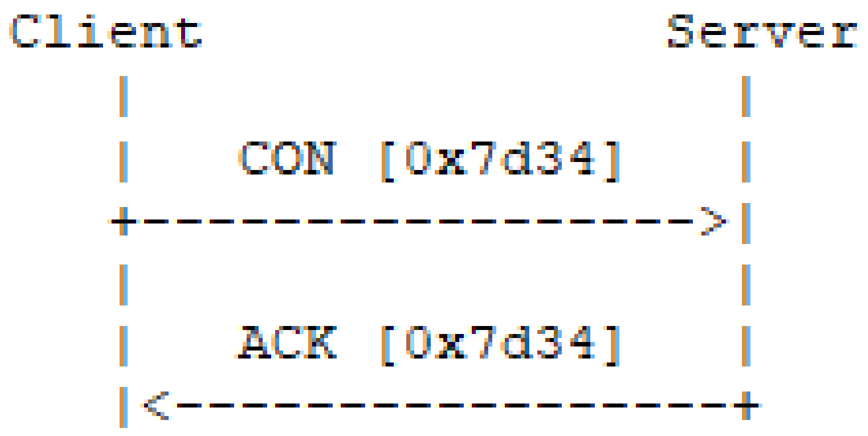


Figure 2: reliable Message Transmission

## Non-confirmable and RST

- When a recipient is not at all able to process a Confirmable message(i.e., not even able to provide a suitable error response), it replies with a **Reset message (RST)** instead of an Acknowledgement(ACK).
- A message that does not require reliable transmission (for example, each single measurement out of a stream of sensor data) can be sent as a **Non-confirmable** message (NON).

- These are **not acknowledged**, but still have **a Message ID for duplicate detection** (in this example,0x01a0); see Figure 3.
- When a recipient is not able to process a Non-confirmable message, it may reply with a **Reset message (RST**)

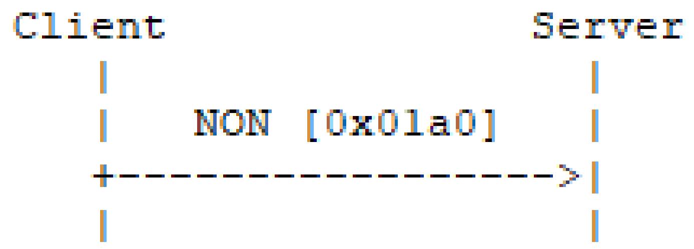


Figure 3: Unreliable Message Transmission

## Request/Response Model

- CoAP request and response semantics are carried in CoAP messages, which include either a Method Code or Response Code, respectively.
- **Optional (or default) request and response information, such as the URI and payload media type are carried as CoAP options**.
- Coap message contains token length and token.

# Token

- A Token is used to match responses to requests independently from the underlying messages
- Tokens are chosen by the client and help to identify request/response pairs that span several message exchanges (e.g., a separate response, which has a new MID).
- Servers do not generate Tokens and only mirror what they receive from the clients.
- Tokens must be unique within the namespace of a client throughout their lifetime.
- This begins when being assigned to a request and ends when the open request is closed by receiving and matching the final response.

- A **request** is carried in a Confirmable (**CON**) or Non-confirmable (**NON**) message, and, if immediately available, the **response** to a request carried in a Confirmable message is carried in the resulting Acknowledgement (**ACK**) message. This is called a **piggybacked** response (There is no need for separately acknowledging a piggybacked response, as the client will retransmit the request if the acknowledgement message carrying the piggybacked response is lost.)
- CoAP makes use of GET, PUT, POST, and DELETE methods in a similar manner to HTTP

```
    Client              Server       Client              Server
       |                  |             |                  |
       |   CON [0xbc90]   |             |   CON [0xbc91]   |
       | GET /temperature |             | GET /temperature |
       |   (Token 0x71)   |             |   (Token 0x72)   |
       +----------------->|             +----------------->|
       |                  |             |                  |
       |   ACK [0xbc90]   |             |   ACK [0xbc91]   |
       |   2.05 Content   |             |  4.04 Not Found  |
       |   (Token 0x71)   |             |   (Token 0x72)   |
       |     "22.5 C"     |             |   "Not found"    |
       |<-----------------+             |<-----------------+
       |                  |             |                  |
```

Figure 4: Two GET Requests with Piggybacked Responses

- If the server is not able to respond immediately to a **request** carried in a **Confirmable message**, it simply responds with an **Empty Acknowledgement** message so that the client can stop retransmitting the request.

- When the response is ready, the server sends it in a new **Confirmable message** (which then in turn needs to be acknowledged by the client). This is called a "separate response", as illustrated i Figure 5.

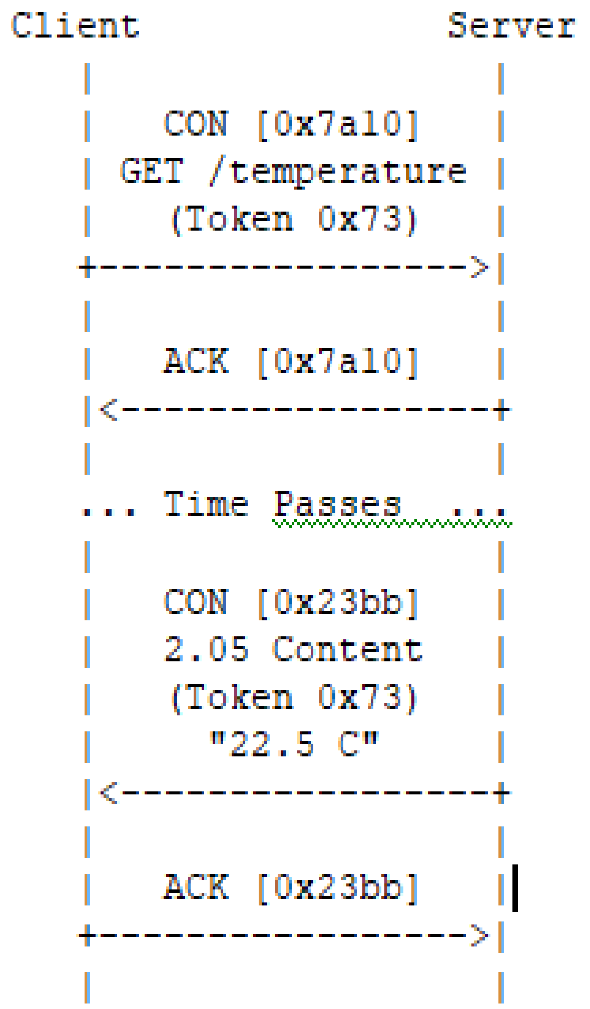


Figure 5: A GET Request with a Separate Response

- If a request is sent in a Non-confirmable message, then the response is sent using a new Non-confirmable message, although the server may instead send a Confirmable message. This type of exchange is illustrated in Figure 6.

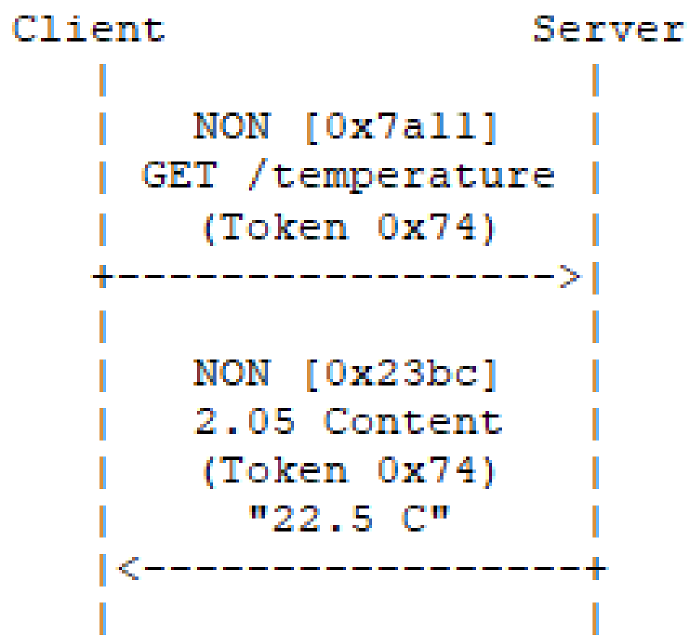


Figure 6: A Request and a Response Carried in Non-confirmable Messages

## Reset Message

- A Reset message indicates that a specific message (Confirmable or Non-confirmable) was received, but some context is missing to properly process it.
- This condition is usually caused when the receiving node has rebooted and has forgotten some state that would be required to interpret the message

```
Message Format
0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Ver| T |  TKL  |      Code     |          Message ID           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Token (if any, TKL bytes) ...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Options (if any) ...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |1 1 1 1 1 1 1 1|    Payload (if any) ...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

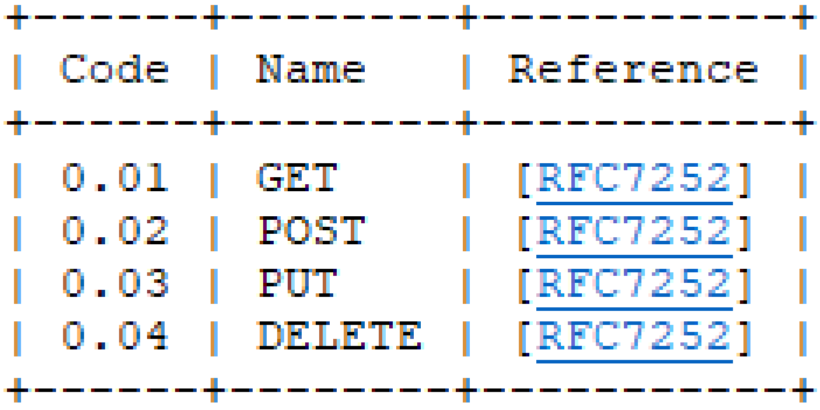
Figure 7: Message Format

- Version (Ver):
  - 2-bit unsigned integer.
  - Indicates the CoAP version number.
  - Implementations of this specification MUST set this field to 1 (01 binary).
  - Other values are reserved for future versions.
  - Messages with unknown version numbers MUST be silently ignored.
- Type (T): 2-bit unsigned integer. Indicates if this message is oftype Confirmable (0), Non-confirmable (1), Acknowledgement (2), or Reset (3).

- Token Length (TKL): 4-bit unsigned integer. Indicates the length of the variable-length Token field (0-8 bytes).
  - Lengths 9-15 are reserved, MUST NOT be sent, and MUST be processed as a message format error.

- Code:  8-bit unsigned integer, split into a 3-bit class (most significant bits) and a 5-bit detail (least significant bits),documented as "c.dd" where "c" is a digit from 0 to 7 for the3-bit subfield and "dd" are two digits from 00 to 31 for the 5-bitsubfield.
- The class can indicate a request (0), a success response (2), a client error response (4), or a server error response (5).

- In case of a request, the Code field indicates the Request Method; in case of  a response, a Response Code.



| Code | Name | Reference |
|---|---|---|
| 0.01 | GET | [RFC7252] |
| 0.02 | POST | [RFC7252] |
| 0.03 | PUT | [RFC7252] |
| 0.04 | DELETE | [RFC7252] |

- All other Method Codes are Unassigned.

There are 3 classes of Response Codes:

- 2 - Success:  The request was successfully received, understood, and accepted.
- 4 - Client Error:  The request contains bad syntax or cannot be fulfilled.
- 5 - Server Error:  The server failed to fulfill an apparently valid request.

- Response code:
- **2.01 Created**
- **2.02 Deleted**
- **…**
- **2.05 Content**
- **…**
- **4.00 Bad Request**
- **…**
- **4.03 Forbidden**
- **4.04 Not Found**
- **…**
- **5.00 Internal Server Error**

- Message ID: 16-bit unsigned integer in network byte order. Used to detect message duplication and to match messages of type Acknowledgement/Reset to messages of type Confirmable/Non-confirmable.
- The header is followed by the Token value, which may be 0 to 8 bytes, as given by the Token Length field. The Token value is used to correlate requests and responses.
- Header and Token are followed by zero or more Options. An Option can be followed by the end of the message, by another Option, or by the Payload Marker and the payload.
- Optional (or default) request and response information, such as the URI and payload media type are carried as CoAP options.