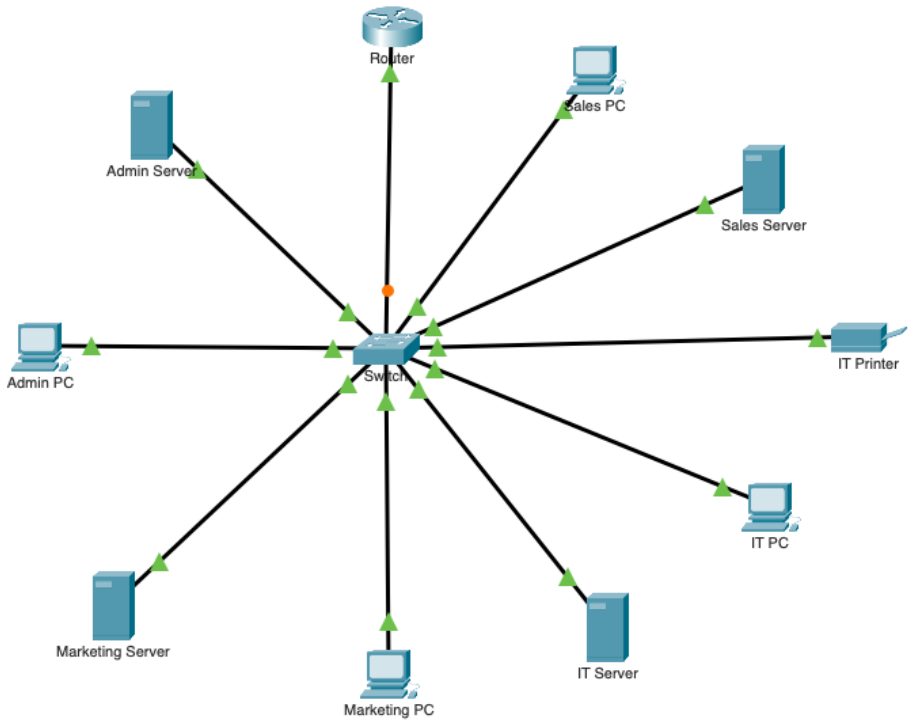
Project Documentation: Network Design and Signal Analysis

1. **Overview:** This documentation details the design and implementation of a departmental network infrastructure and an analysis of digital signal quantization. The project successfully establishes a functional network with inter-VLAN routing and application services while evaluating the trade-offs in signal sampling precision.

2. **Network Topology & Architecture**

2.1 Network Structure: The network utilizes a star topology centered around a switch, connecting various departmental devices for role separation and functionality.

- **Departmental Segmentation:** The organization is logically divided into four departments: Admin, Sales, Marketing, and IT.
- **Star Topology Implementation:** A central switch connects all PCs, servers, and a shared IT printer to ensure efficient resource sharing
- **Core Components:**
  - **Central Switch:** Connects all PCs, servers, and shared units.
  - **Router:** Facilitates inter-VLAN communication and future external connectivity.
  - **Infrastructure Components:** The design includes specific servers for each department and a router to handle inter-VLAN and future external communications.



Logical network topology connecting all PCs, servers, router, and printer via a central switch to establish connectivity.

2.2 VLAN Configuration and Port Mapping: The network is segmented into four primary VLANs to manage traffic and security.

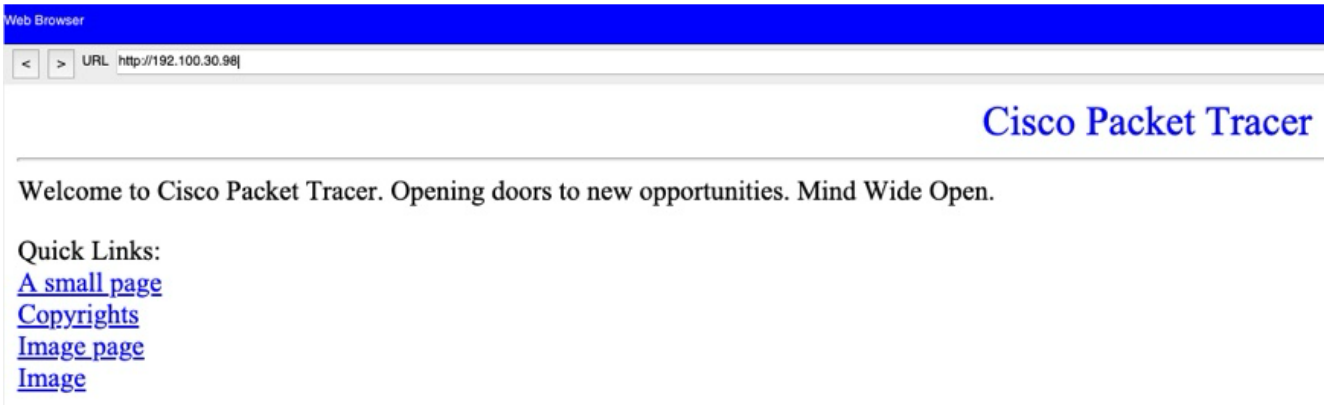
VLAN	Name	Assigned Ports
10	MARKETING	Fa0/4, Fa0/5
20	ADMIN	Fa0/2, Fa0/3
30	IT	Fa0/6, Fa0/7, Fa0/10
40	SALES	Fa0/8, Fa0/9

2.3 Inter-VLAN Routing (Router-on-a-Stick): Inter-VLAN communication is enabled via a router configured with 802.1Q encapsulation on sub-interfaces.

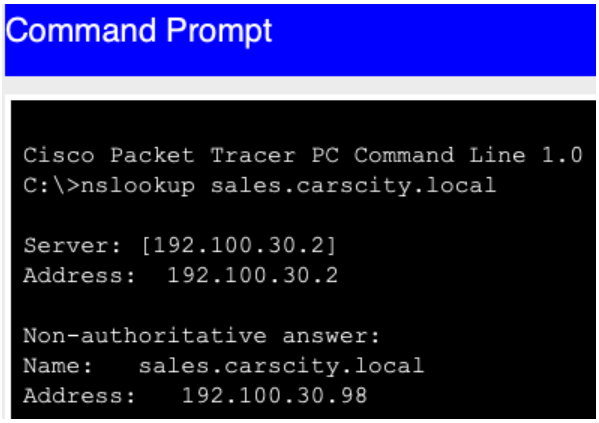
- **G0/0.10:** 192.100.30.1 (Marketing Gateway)
- **G0/0.20:** 192.100.30.33 (Admin Gateway)
- **G0/0.30:** 192.100.30.65 (IT Gateway)
- **G0/0.40:** 192.100.30.97 (Sales Gateway)

2.4 Application Services

- **Web Hosting:** A web application is hosted on the Sales Server (192.100.30.98), accessible via HTTP over TCP.
- **DNS Resolution:** A DNS server (192.100.30.66) resolves domain names such as sales.carscity.local.

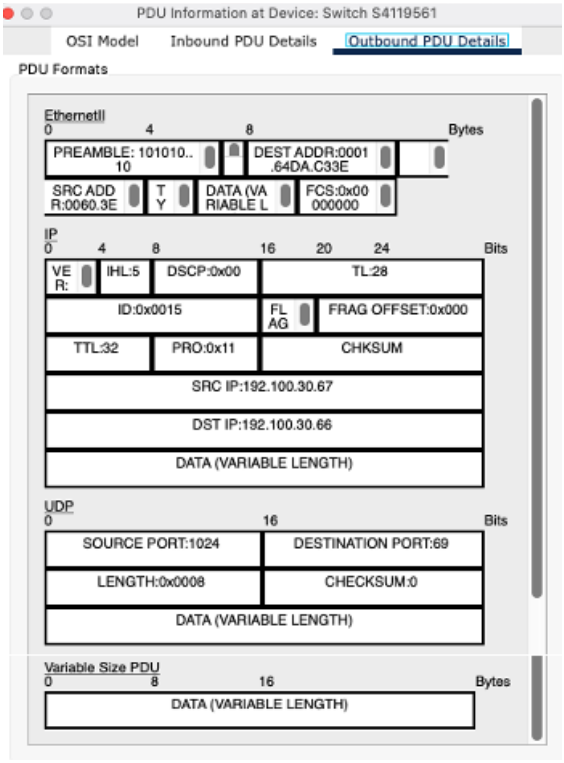


Web application hosted on the Sales Server, accessible via HTTP over TCP.

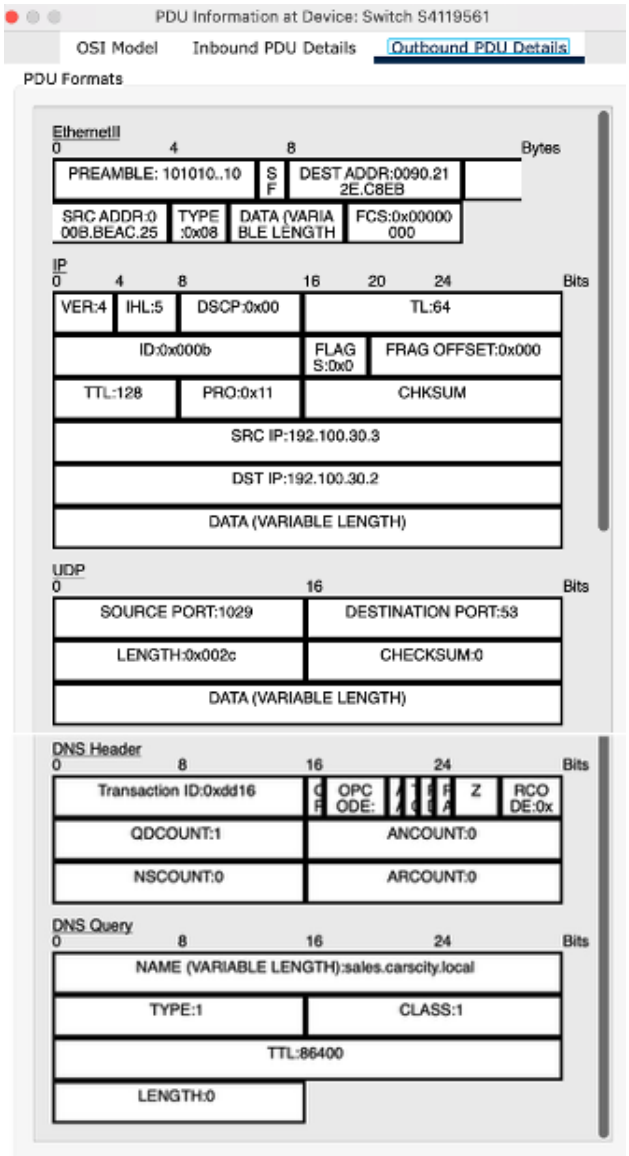


Resolution of the domain name sales.carscity.local using the DNS server, showing the mapped IP address.

3. **Protocol & Traffic Analysis:** To verify that the network was communicating correctly, I performed a deep-packet inspection of the PDUs (Protocol Data Units) at the Switch.
    - **Layer 2 (Ethernet):** Displays the Preamble and MAC addresses (Source: 0060.3E... to Destination: 64DA.C33E...).
    - **Layer 3 (IP):** Shows the packet routing from the IT Server (192.100.30.67) to the IT PC (192.100.30.66).
    - **Layer 4 (Transport):** Shows the use of **UDP** (Protocol 0x11) with a destination port of 69 (TFTP) or 53 (DNS) depending on the captured flow.
    - **Layer 7 (Application):** Captured the actual **DNS Query** for sales.carscity.local, confirming that the application layer is successfully requesting domain resolution.



General PDU analysis showing Layer 2 through Layer 4 encapsulation for internal data exchange.



Detailed DNS Query capture verifying Layer 7 name resolution for "sales.carscity.local".

4. **Quantization and Signal Sampling:** The analog signal was sampled at various intervals and converted into 3-bit and 8-bit digital outputs.

Timestamp	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Estimated	0.2	0.2	0.3	0.5	0.7	1.5	1.3	1.2	1.3	1.1
3-bit output	001	001	001	010	011	111	110	101	110	101
8-bit output	32	32	48	80	112	240	208	192	208	176

Technical Observations: For each time instant between 0 and 9 ms, the analog signal was rounded to the nearest quantization level. In the 3-bit example, the 0–1.6 V range was divided into eight levels of roughly 0.2 V. At 3 ms, for example, the signal is roughly 0.5 V, which is roughly 2.5 divided by 0.2 and rounds to level 2, or binary 010. In the 8-bit example, the same range was divided into 256 much smaller steps of roughly 0.00625 V each. In the meantime, 0.5 divided by 0.00625 is about 80, or the decimal 80 and binary 01010000. The same was done for every one of the timestamps to complete filling in the results table.

5. **Connectivity Verification**
   - **Intra-VLAN Connectivity:** Verified by a successful ping from Marketing PC to its default gateway (192.100.30.1).

```
C:\>ping 192.100.30.1

Pinging 192.100.30.1 with 32 bytes of data:

Reply from 192.100.30.1: bytes=32 time=8ms TTL=255
Reply from 192.100.30.1: bytes=32 time=4ms TTL=255
Reply from 192.100.30.1: bytes=32 time=4ms TTL=255
Reply from 192.100.30.1: bytes=32 time=4ms TTL=255

Ping statistics for 192.100.30.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 4ms, Maximum = 8ms, Average = 5ms
```

Ping from Marketing PC to its default gateway (192.100.30.1) showing successful communication within VLAN 10.

   - **Inter-VLAN Connectivity:** Successfully demonstrated through a ping from the Admin PC (VLAN 20) to the IT Server (VLAN 30) via the router.

```
C:\>ping 192.100.30.66

Pinging 192.100.30.66 with 32 bytes of data:

Reply from 192.100.30.66: bytes=32 time=8ms TTL=127
Reply from 192.100.30.66: bytes=32 time=8ms TTL=127
Reply from 192.100.30.66: bytes=32 time=9ms TTL=127
Reply from 192.100.30.66: bytes=32 time=8ms TTL=127

Ping statistics for 192.100.30.66:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 8ms, Maximum = 9ms, Average = 8ms
```

Ping from Admin PC (VLAN 20) to IT Server (192.100.30.66, VLAN 30) demonstrating successful inter-VLAN routing via Router-on-a-Stick.

6. **Conclusion:** The implemented network provides a reliable and scalable foundation for organizational communication. The quantization analysis further highlights that the choice of bit depth is a critical trade-off between system efficiency and signal fidelity.

7. **Technical Appendix**

- VLAN Configuration and Port Mapping

```
Switch>show vlan brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/11, Fa0/12, Fa0/13, Fa0/14
                                                Fa0/15, Fa0/16, Fa0/17, Fa0/18
                                                Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                                Fa0/23, Fa0/24, Gig0/1, Gig0/2
10   MARKETING                        active    Fa0/4, Fa0/5
20   ADMIN                            active    Fa0/2, Fa0/3
30   IT                               active    Fa0/6, Fa0/7, Fa0/10
40   SALES                            active    Fa0/8, Fa0/9
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
```

Switch CLI output confirming VLANs 10 (Marketing), 20 (Admin), 30 (IT), and 40 (Sales) with appropriate port assignments.

- Router-on-a-Stick Configuration

```
Router#show running-config | begin GigabitEthernet0/0.10
interface GigabitEthernet0/0.10
 encapsulation dot1Q 10
 ip address 192.100.30.1 255.255.255.224
!
interface GigabitEthernet0/0.20
 encapsulation dot1Q 20
 ip address 192.100.30.33 255.255.255.224
!
interface GigabitEthernet0/0.30
 encapsulation dot1Q 30
 ip address 192.100.30.65 255.255.255.224
!
interface GigabitEthernet0/0.40
 encapsulation dot1Q 40
 ip address 192.100.30.97 255.255.255.224
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
 shutdown
!
```

Router sub-interfaces G0/0.10, G0/0.20, G0/0.30, and G0/0.40 configured with 802.1Q encapsulation and IP addresses for inter-VLAN routing.