Universidad Carlos III de Madrid

GRADO EN INGENIERÍA EN TECNOLOGÍAS DE TELECOMUNICACIÓN
Aplicaciones Telemáticas
Evaluación Extraordinaria
(90 minutes) 21-06-2022 - Page 1

Información importante

Esta solución se proporciona con el propósito de que los alumnos dispongan de una corrección del examen realizado. Es posible que existan defectos en la solución en cuyo caso se solicita se comuniquen a dds@it.uc3m.es.

Instructions

- SOLVE PROBLEMS IN SEPARATED PAGES AND RETURN THIS EXAM PAGES WITH YOUR NAME ON IT
- Total time 120 minutos (30 test + 90 problems). The test will be collected 30 minutes after the exam starts
- You can use any reasonable assumption (used in class) but you must explicitly state that you do it and what that assumption is, by briefly explaining it.
- Explain everything you do since the results provided without an explanation may not count for the grade

Problem 1 - HTTP-EMAIL

A company has 3000 small devices of Internet of Things under testing in several homes to assist elder people. Any device in general should regularly be updated, but these devices as they are being tested, are updated even more frequently.

As it is shown in Fig. 1, the company has a central domain called `iot.com` en la zona DNS `iot.com`. Inside that central zone, there is a SMTP server (`mail.iot.com`) and also a HTTP server (`parches.iot.com`).

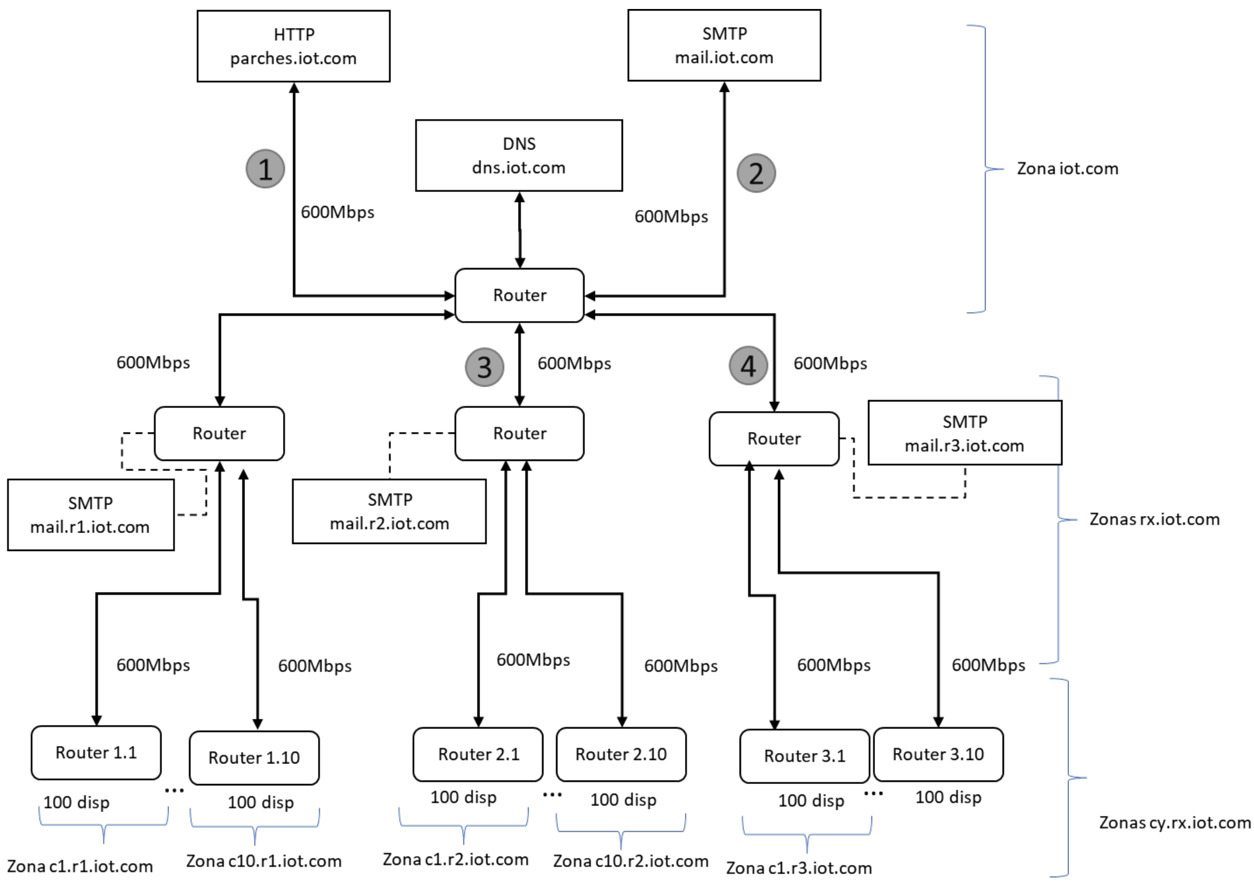

Figura 1: Network diagram

The company has an international profile so it have divided the devices among regions. Every region has a domain name like `rx.iot.com` where `x` can be a number from 1 to 3 (i.e. `r1.iot.com` for region 1). Inside each region there is a SMTP server (`mail.rx.iot.com`) but there is **NO** HTTP server. Every region is a DNS zone thus, it has its own DNS servers (that are not shown in the figure due to space constraints) with the name `dns.rx.iot.com` for the primary server.

Finally, every region groups 10 countries (so there are 30 countries in total), and each country is a DNS zone `cy.rx.iot.com` whre `y` ranges from 1 to 10. Every country has its own DNS primary server, for instance, country number 1 within region 2 DNS server will have the name `dns.c1.r2.iot.com`.

There are 100 devices per country so, 10 countries per region, in 3 different regions sums $10 * 3 * 100 = 3000$ devices.

In order to distribute the patches, several approaches are evaluated to determine their effectiveness. The company have chosen you to do the calculations.

The first approach consists on distributing the patches over HTTP. The server called `parches.iot.com` is available for downaloading patches from it using HTTP. Every patch is 10 MBytes long and is type is equivalent to `application/gzip` or `application/octet-stream` (both types are equivalent so use the one you like the most). Devices verify regularly if there is a new patch available for updating their software. If so, they directly download it.

1. **(1 pt)** What would be the worst scenario (worst case)? In that worst case, what would be the available bandwidth for every device in the link marked as 1 in Fig. 1? Explain your reasoning.

   Note: You can estimate the bandwidth distributing statistically the available end to end link reasoning why. Be sure you describe what the worst case would be and the available bandwidth in that case.

   Sol:

   The worst case scenario would be where all devices decide to download the patch from the server at the same time.

   Regarding the estimated bandwidth per device, we will assume that the most loaded link is 1 and therefore the router connecting the patch server to the rest of the devices will start dropping packets when congestion occurs. The devices, noticing the packet loss, will apply the congestion mechanisms by reducing the window. If we consider that the router shares its processing time equally, hypothetically, the end-to-end bandwidth of each device would eventually converge to a fraction of the shared link with the lowest capacity.

   So, in the best case scenario for this worst case, the bandwidth available to each device would be $600000000/3000 = 200000bps = 200Kbps$.

2. **(1 pt)** Calculate the window that allows continuous sending considering the end-to-end bandwidth of the worst case.

Note: The end to end transmission delay, so from the device to the server is 50ms. The MTU is 1460 Bytes and MSS 1420 Bytes.

Sol:

The MSS parameter of 1420 Bytes (MTU of 1460) is unusual.

The value of V_{ec}, the continuous sending window, allows the bandwidth to be used to the maximum, and it is not possible to do better. It is a matter of calculating how many segments can be transmitted in the RTT time (that a segment in flight takes to reach its destination and that the destination settles it by freeing a space in the window after its reception at the origin).

Considering that each device would have a 200Kbps link, we calculate the transmission time as $t_{tx} = MTU/v = (1460 * 8)/200000 = 0{,}0584 = 58{,}4ms$. The ACK transmission time would be $t_{txACK} = 40/v = (40 * 8)/200000 = 0{,}0016 = 1{,}6ms$ and therefore the RTT will be $RTT = t_{tx} + t_{txACK} + 2 * tp = 58{,}4 + 1{,}6 + 2 * 50 = 160ms$.

For the calculation of the continuous sending window we will calculate how many transmission times fit in one RTT, so $v_{ec} = RTT/t_{tx} = 160/58{,}4 = 2{,}73$.

This should warn us that, in the best case, no more than 2 complete segments can be sent per RTT.

3. **(1 pt)** If the URL of the patch is `http://parches.iot.com/LATEST.gz`, write down **the HTTP 1.1 request** that the device should send to the server to download the patch and **the response** considering the size of the patch, the content type and considering the response could be used by the device to find out if the patch has been updated.

After connecting from the device to the HTTP server `parches.iot.com`, the request will be sent:

```
GET /LATEST.gz HTTP/1.1
host: parches.iot.com
```

When using the response to determine the date of the patch (not the response) it is necessary to include the `Last-Modified` or `etag` headers for the device to determine if it is the latest version. On the other hand it is necessary to include `Content-Length` (as any response) as well as `Content-Type`

```
HTTP/1.1 200 OK
Date: Mon, 12 Jun 2022 22:42:01 GMT
Last-Modified: Mon, 23 May 2022 17:40:26 GMT
Content-Length: 10485760
Content-Type: application/octet-stream
```

4. **(1 pt)** How long (in RTT and seconds) will take a device to fully download a patch in the worst case?

   Note: for this calculation you can discard the HTTP headers in the response (as if the patch is downloaded using raw TCP) [1]

   Sol:

   The file to be sent is 10Mb, which is 1000000 bytes. Given that the MSS is 1420, it would be necessary to send $10000000/1420 = 7042,25 \approx 7043$ segments.

   We would start from the client with $cwnd = 1$ sending the request to the server, which would reply with the first segment and the ACK, so the client window would go to $cwnd = 2$ while the server window would remain at $cwnd = 1$. The client would send an ACK, to the server, so the server window would go to $cwnd = 2$. Subsequently the server sends segments D2 and D3 of the patch, receiving both ACKs from the client, the server would have $cwnd = 4$.

   From this moment on $cwnd > V_{ec}$, so in each RTT it will not be able to send more than 2.7 segments (considering complete segments, we are talking about 2 segments per RTT).

   So far, 3 segments have been sent and 1.5 RTTs have been used to establish the connection, and 2.5 RTTs have been used to send the request, and the server sends the three segments as well as the respective ACKs of all the segments (3 segments, 4 RTTs).

   From this moment on, it will be necessary to send 7040 segments, and for each RTT no more than 2 can be sent, as this limits the continuous sending window. Therefore, $7040/2 = 3520$ RTTs will be necessary.

   Considering the connection closure, the total would be $4 + 3520 + 1,5 = 3525,5$ RTTs. In seconds $3525{,}5 * 160ms = 564080ms = 564{,}08s$.

[1] To calculate the size of the file you can use either IEC standard $1MB = 1000000$ bytes not the traditional way $1MB = 1024*1024$ Bytes

The second approach is to give an email address to every device. Accodring to the description and the figure, every region has its own email server (but countries have no email servers), so every region will handle the emails of 10 countries thus, 1000 devices. The email address of every device will be, for instance, `disp1-c1@r1.iot.com` for device numer 1, in country number 1, within region number 1.

When a new patch is published, an email is delivered from the address `parches@iot.com` to every of the 3000 devices with the patch as an attachment.

If the default SMTP server for zone iot.com is `mail.iot.com` and the email is sent from `parches.iot.com`, answer the following questions:

5. **(1 pt)** Write down the SMTP trace generated from MTA `mail.iot.com` to `mail.r1.iot.com` when the email is sent to the device with email address `disp1-c1@r1.iot.com`
   Nota: It is not necessary to write the RFC822 mail in the trace, just use `<mail>` as a placeholder

   Sol:
   The RFC822 mail (which would go in the `<email>` slot) must be terminated with a `.`

```
S: 220 mail.r1.iot.com ready ...
C: HELO mail.iot.com
S: 250 mail.r1.iot.com
C: MAIL FROM: parches@iot.com
S: 250 OK
C: RCPT TO: disp1-c1@r1.iot.com
S: 250 OK
C: DATA
S: 354
<email>
.
S: 250 OK
C: QUIT
S: 221
```

6. **(1 pt)** Write down the email in RFC822 format to is delivered to `disp1-c1@r1.iot.com`. Remember it transports a file.

   Sol:

   It must have at least the MIME and Content-Type headers. The simplest email would be:

   ```
   From: parches@iot.com
   To: disp1-c1@r1.iot.com
   Subject: Parche
   MIME-Version: 1.0
   Content-Type: application/gzip
   ```

7. **(1 pt)** Is this way of distributing patches improving the situation of question 1?

   Solution partially developed (open problem):

   There are several possible answers, one of which is explained but not developed (the problem is open).

   First of all, we need to think about the wording, since it indicates that the patch is sent by mail **"to each of the 3000 devices with the patch attached"**.

   If a mail is sent individually to each device, it has to send 3000 mails, so the problem is going to be more or less similar (maybe worse if we consider the MIME encoding of the patch). It won't be much better, therefore, in this case.

   If you send a mail with all the devices in CC it is more than possible that the server will not allow it to be sent because there are too many of them, but considering that you could, in that case it would be better because you would only send one mail until you reach the regional MTAs. In that case it would work much better, but it is not what it says (exactly) in the statement.

8. **(1.5 pts)** How would you improve the use of resources using mail instead of sending an email per device?

   Solution partially developed (open problem):

   If you create distribution lists per region you would send only three mails (only one recipient which is actually a distribution list) at the top of the infrastructure (one per region) and then each region has the same bandwidth to be distributed among 1000 only. It would improve the patch distribution problem quite a lot.

Another issue is to allow devices to read a single mail address. For this to work, there should be a common address for devices in each region. The resulting problems could be many since some device could delete the mail. Although this is not described in the statement, it is an alternative that can be applied here (since the problem is open). However, it would not improve on the use of distribution lists.

9. **(1.5 pts)** If instead of having a single HTTP server to distribute patches the company uses three different servers for parches.iot.com, every of them with its own IP address and its own 600 Mbps link, How would you do to evenly distribute the load among the three servers?

   Solution

   There are no several possible answers here.

   You would have to put all three address records in the DNS server for the domain name patches.iot.com. Usually DNS servers distribute by default using round robin, so statistically each server would be used by only one third of the devices.

   This has been seen in the lab (DNS load balancing).

DNS Problem

The `amigos.com` zone administrator's email is `admin-amigos@ionos.es`.
The `vip.amigos.com` zone administrator is `vip@vip.com`. Additionally, `muy.amigos.com` is a subdomain of amigos.com.

1. **(2.5 pts)** Explain the difference between DNS zones and domains. **1 pt**) **Sol:**
   DNS zones are operated independently, while domains are operated by the same administrator as the domain ancestor.

2. **(2.5 pts)** There are at least two types of resource records that exist both in `amigos.com` and `vip.amigos.com` and do not exist in `muy.amigos.com`. Which? **Sol:**
   NS, SOA (and optionally MX which may happen to be defined in subdomains but it MUST be defined in zones)

   Write down the content of both resource records (invent the values you are given no data). **(1 pt)** SOA: ns1.amigos.com. admin-amigos.ionos.es. 2022061303 7200 7200 2592000 86400

NS: ns1.amigos.com. (and optionally MX: 10 mx1.amigos.com.)

3. **(2.5 pts)** The A record of `www.amigos.com` is changed at time= T_0. The content is changed and also the TTL is changed. The TTL of the old record was 86400 and the TTL of the new record is 5. If a web client makes a first web request at $T_0 - 5$ and a second request at $T_0 + i, i \in \mathbb{N}, i > 0$. What are the values of i ensuring the second request will be served by the new server address? Explain your answer.

   Sol:

   If $i > 86395$ the cache expires and the client request will served from the the new address.

4. **(2.5 pts)** Following with the previous question, imagine that the host where the web client is running is also running bash in a terminal, and at time=$T_0 + 1$ the user executes the command `dig www.amigos.com @ns1.amigos.com`. What are the values of i ensuring the second request (made at $T_0 + i$) will be served by the new server address? Explain your answer.

   Sol:

   At $T_0 + 1$ the cache contents will be replaced by the new Authoritative Answer contents, and subsequent web requests $i > 1$ will be served by the new server address.