DanaBleed: DanaBot C2 Server Memory Leak Bug | ThreatLabz

By ThreatLabz

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Technical Analysis

The DanaBleed memory leak began with the release of DanaBot version 2380 in June 2022 and continued until early 2025.

Analysis of the DanaBleed vulnerability

DanaBot is written in the Delphi programming language and uses a custom binary C2 protocol. A general overview of C2 requests prior to the June 2022 version update was the following:

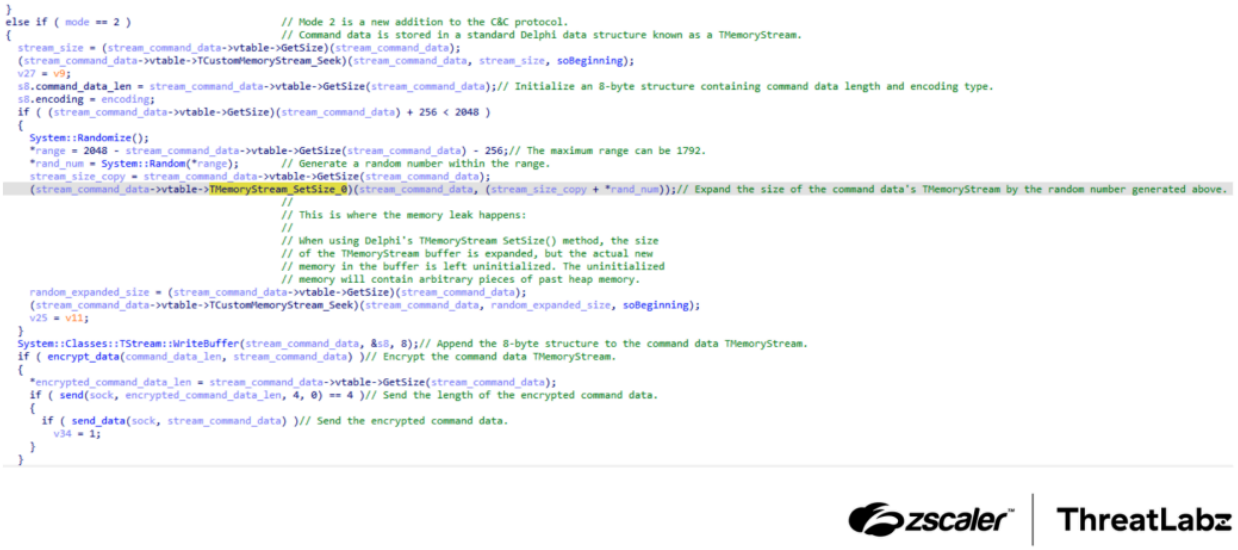
1. Generate command data (e.g. key exchange, system information beacon, configuration file download, additional payload download, new C2 information, etc.)
2. Encrypt data with a session key
3. Encrypt session key
4. Generate a basic header
5. Send header and encrypted data

In June 2022, the malware developer introduced a new C2 protocol that modified the requests to perform the steps below:

1. Generate command data (e.g. key exchange, system information beacon, configuration file download, additional payload download, new C2 information, etc.)
2. Ostensibly append randomly generated bytes (although they were not random)
3. Encrypt data with a session key
4. Encrypt session key
5. Send encrypted data length and data

Responses from the C2 server to the victim were generated using the same logic and likely the same underlying code as the malware itself. This overlap allowed us to reverse engineer the vulnerability and make inferences about how the C2 server memory leak worked.

The figure below illustrates the changes to the C2 protocol introduced in the June 2022 update:



```
}
else if ( mode == 2 )                   // Mode 2 is a new addition to the C&C protocol.
{                                       // Command data is stored in a standard Delphi data structure known as a TMemoryStream.
  stream_size = (stream_command_data->vtable->GetSize)(stream_command_data);
  (stream_command_data->vtable->TCustomMemoryStream_Seek)(stream_command_data, stream_size, soBeginning);
  v27 = v9;
  s8.command_data_len = stream_command_data->vtable->GetSize(stream_command_data);// Initialize an 8-byte structure containing command data length and encoding type.
  s8.encoding = encoding;
  if ( (stream_command_data->vtable->GetSize)(stream_command_data) + 256 < 2048 )
  {
    System::Randomize();
    *range = 2048 - stream_command_data->vtable->GetSize(stream_command_data) - 256;// The maximum range can be 1792.
    *rand_num = System::Random(*range);       // Generate a random number within the range.
    stream_size_copy = stream_command_data->vtable->GetSize(stream_command_data);
    (stream_command_data->vtable->TMemoryStream_SetSize_0)(stream_command_data, (stream_size_copy + *rand_num));// Expand the size of the command data's TMemoryStream by the random number generated above.
                                        //
                                        // This is where the memory leak happens:
                                        //
                                        // When using Delphi's TMemoryStream SetSize() method, the size
                                        // of the TMemoryStream buffer is expanded, but the actual new
                                        // memory in the buffer is left uninitialized. The uninitialized
                                        // memory will contain arbitrary pieces of past heap memory.
    random_expanded_size = (stream_command_data->vtable->GetSize)(stream_command_data);
    (stream_command_data->vtable->TCustomMemoryStream_Seek)(stream_command_data, random_expanded_size, soBeginning);
    v25 = v11;
  }
  System::Classes::TStream::WriteBuffer(stream_command_data, &s8, 8);// Append the 8-byte structure to the command data TMemoryStream.
  if ( encrypt_data(command_data_len, stream_command_data) )// Encrypt the command data TMemoryStream.
  {
    *encrypted_command_data_len = stream_command_data->vtable->GetSize(stream_command_data);
    if ( send(sock, encrypted_command_data_len, 4, 0) == 4 )// Send the length of the encrypted command data.
    {
      if ( send_data(sock, stream_command_data) )// Send the encrypted command data.
        v34 = 1;
    }
  }
```


Figure 1: Overview of C2 protocol changes introduced in DanaBot in the June 2022 update.

DanaBot's command data was stored in a Delphi TMemoryStream. A random number, capped at a maximum value of 1,792, was generated to determine the number of padding bytes to add to the command data buffer. While the size of the buffer was increased, the newly allocated memory within the buffer was *not* initialized. At first glance, this uninitialized memory appeared to be random, but closer inspection revealed that it contained arbitrary fragments of the C2 server's process memory. This oversight in memory handling created the DanaBot vulnerability that exposed the group's sensitive internal data.

Data exposed by the memory leak

The memory leak allowed up to 1,792 bytes per C2 server response to be exposed. The content of the leaked data was arbitrary and depended on the code being executed and the data being manipulated in the C2 server process at a given time. Despite this, our examination of the leaked data allowed us to extract meaningful insight into DanaBot for nearly three years.

Some of the most intriguing leaks revealed HTML snippets associated with the C2 server's web interface. The figure below, with highlights added, provides a sample of these leaked elements.

<h4>You_IP: </td><td><h4>81.8.233.252</td></tr><tr><td align=right><h4>Acc_ID:
</td><td><h4>U000005</td></tr><tr><td align=right><h4>Build_ID:
</td><td><h4>1132ED40DAFD67B2D9D73754DA097967</td></tr><tr><td align=right><h4>Drop_ID:
</td><td><h4>C99D71EBF95F752D1FD6FA9711196BF3</td></tr><tr><td align=right><h4>Key_ID:
</td><td><h4>FC62F86193916F7FE477DCEE59B59318</td></tr><tr><td align=right><h4>Write_Mode:
</td><td><h4>1</td></tr><tr><td align=right><h4>Inject_Mode: </td><td><h4>1</td></tr><tr><td
align=rig

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ign=left size=2></td></tr><tr><td align=right><h4>User:
</td><td><h4>oracle@localhost</td></tr><tr><td align=right><h4>Domain:
</td><td><h4>ockiwumgv77jgrppj4na362q4z6flsm3uno5td423jj4lj2f2meqt6ad.onion:443</td></tr><tr><td
align=right><h4>Administration IP: </td><td><h4>188.92.79.117:35477</td></tr><tr><td
align=right><h4>You_IP: </td><td><h4>145.239.5.30</td></tr><tr><td align=right><h4>Acc_ID:
</td><td><h4>U000005</td></tr><tr><td align=ri

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at><h5>Records: </td><td><h5>497 117</td></tr><tr><td align=right><h5>First Date:
</td><td><h5>2022-2-18</td></tr><tr><td align=right><h5>Last Date:
</td><td><h5>2022-6-27</td></tr><tr><td colspan=15><hr align=left size=2></td></tr></table><table
border=0><tr><td valign=top align=right><table

/tr><tr><td align=right><h4>Full_Threading_Created: </td><td><h4>489</td></tr><tr><td
align=right><h4>Posit_Upload: </td><td><h4>0</td></tr><tr><td colspan=2><hr align=left
size=2></td></tr><tr><td align=right><h4>User: </td><td><h4>pin@localhost</td></tr><tr><td
align=right><

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lign=top align=right><table border=0><tr><td><h4><font color=#0500fe>Install Bot's:
</td><td><h4><font color=#0500fe>110 422</td></tr><tr><td align=right>One Hour:
</td><td>0</td></tr><tr><td align=rig

=2&botid=">https://23.254.253.43:443/accid=5&key=FC62F86193916F7FE477DCEE59B59318&command=2&b
otid=</td><td></td></tr><tr><td><h5>Socks </td><td

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Figure 2: Example of leaked HTML code from DanaBot's C2 server.

These HTML snippets can be compared to the figure below (highlights added) which includes a screenshot from a video advertising DanaBot.

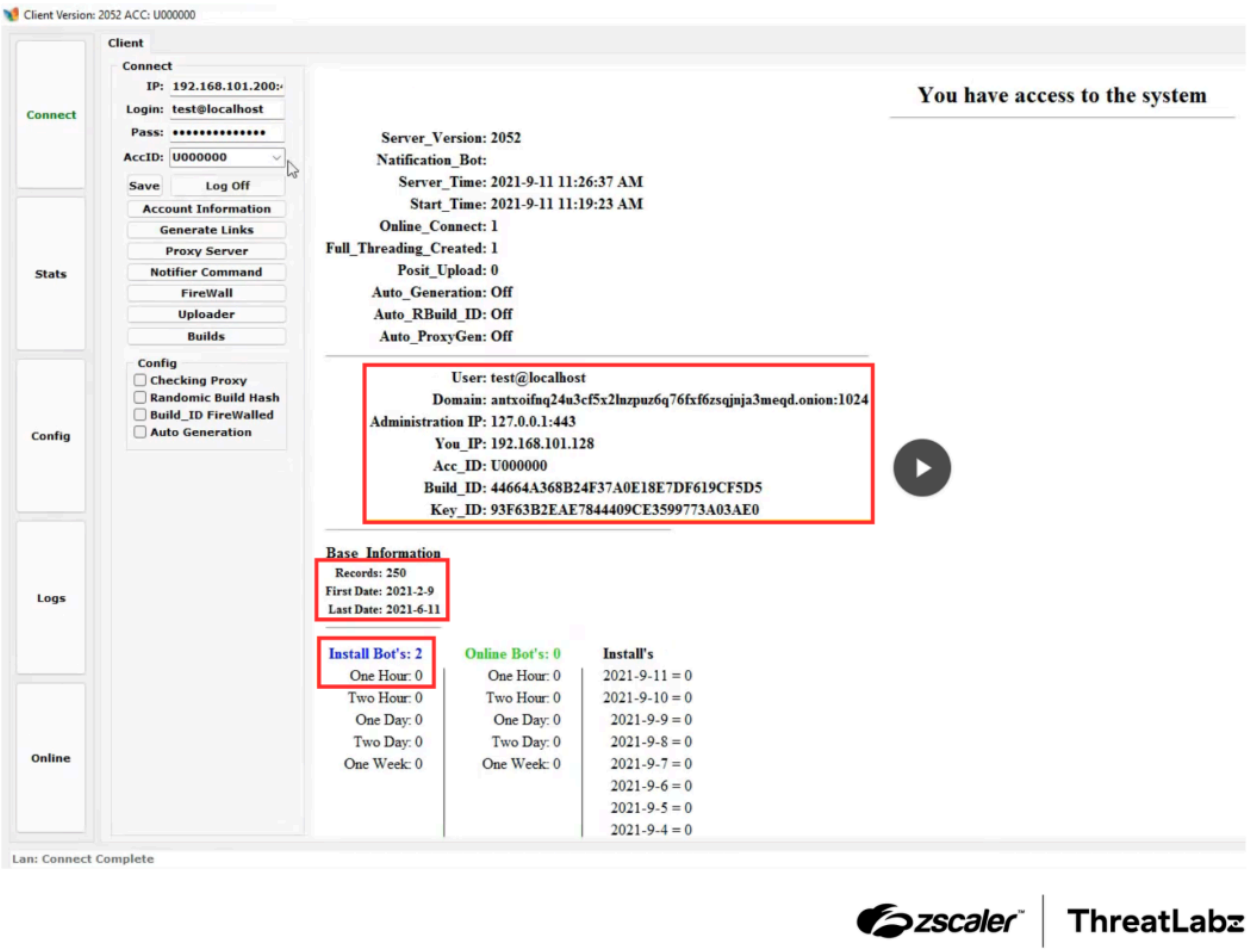

Figure 3: Screenshot from a DanaBot advertisement video with content similar to the data observed in C2 server memory leaks.

The memory leak exposed sensitive data including:

- Threat actor usernames and IP addresses
- Backend C2 server IP addresses and domains
- Infection and exfiltration statistics
- Malware version update information
- Private cryptographic keys
- Victim-related data, such as IP addresses, credentials, and exfiltrated information

The DanaBot developer maintained a changelog of updates and some of those changes were also leaked, as shown in the figure below (highlights added).

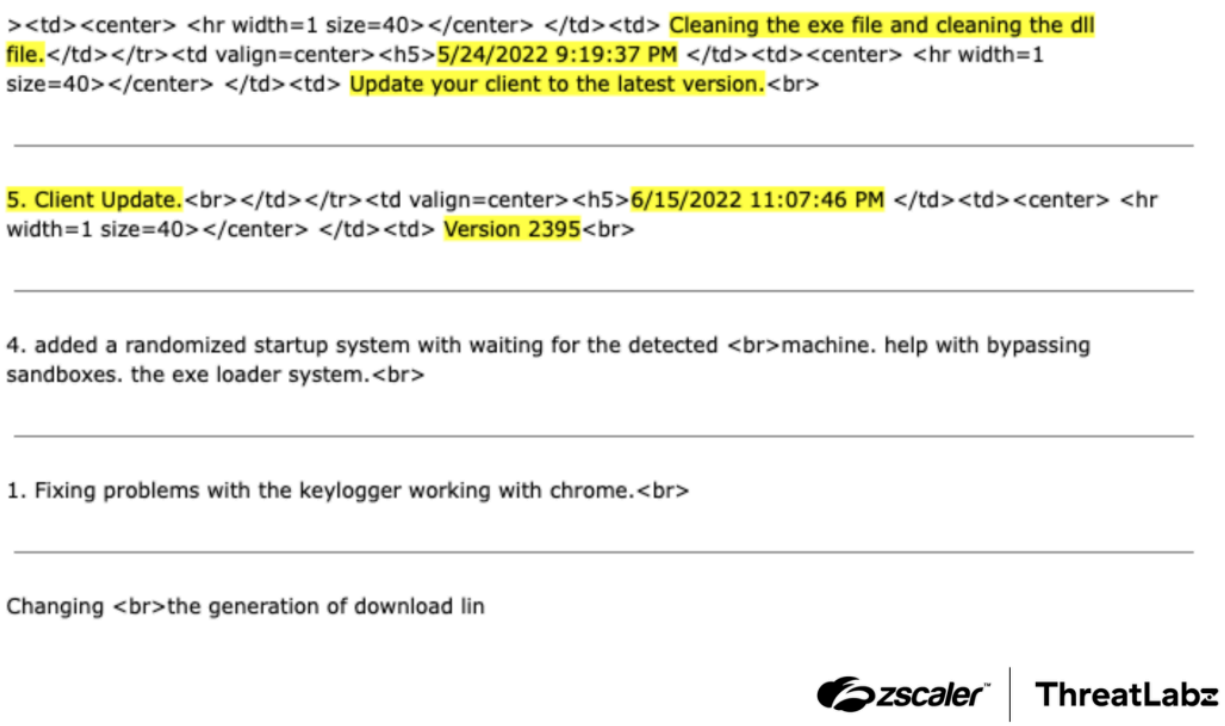

Figure 4: Sample change log discovered in DanaBot C2 server memory leaks.

In addition to HTML snippets, the memory leak also exposed debug information, including pathnames and logging messages. These are demonstrated in the figure below.

Figure 5: Sample debug information identified in DanaBot C2 server memory leaks.

Another frequent type of leak involved SQL statements. These leaks offered valuable insights into the C2 server's database structure, including information such as malware MD5 hashes, version updates, and victim IP addresses. The figure below (with highlights added) provides an example of these leaks.

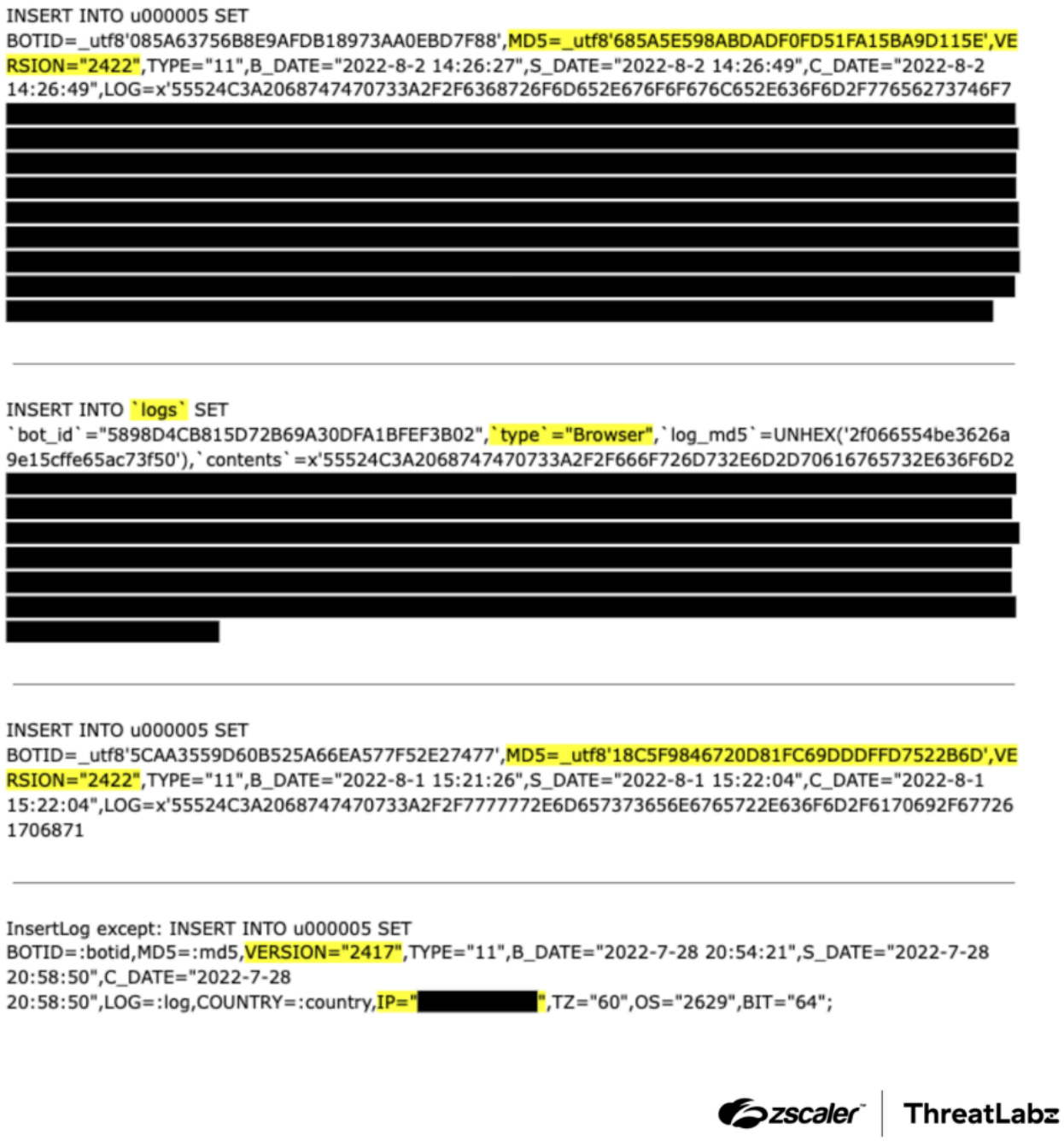

Figure 6: Sample SQL statement leak by DanaBot's C2 server.

The memory leaks also exposed private cryptographic key material, as shown in the figure below (highlight added):

Figure 7: Sample private key material leaks.

Finally, as DanaBot primarily functioned as an information stealer, the memory leak also exposed a significant amount of victim credentials and other exfiltrated data.

Source: https://www.zscaler.com/blogs/security-research/danableed-danabot-c2-server-memory-leak-bug