OSI model

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7. Application layer
• NNTP
• SIP
• SSI
• DNS
• FTP
• Gopher
• HTTP
• NFS
• NTP
• SMPP
• SMTP
• SNMP
• Telnet
• DHCP
• Netconf
• (more)
6. Presentation layer
• MIME
• XDR
5. Session layer
• Named pipe
• NetBIOS
• SAP
• PPTP
• RTP
• SOCKS
• SPDY
4. Transport layer
• TCP
• UDP
• SCTP
• DCCP
• SPX
3. Network layer
• IP
• IPv4
• IPv6
• ICMP
• IPsec
• IGMP
• IPX
• AppleTalk
• X.25 PLP

2. Data link layer
• ATM
• ARP
• SDLC
• HDLC
• CSLIP
• SLIP
• GFP
• PLIP
• IEEE 802.2
• LLC
• L2TP
• IEEE 802.3
• Frame Relay
• ITU-T G.hn DLL
• PPP
• X.25 LAPB
• Q.921 LAPD
• Q.922 LAPF
1. Physical layer
• EIA/TIA-232
• EIA/TIA-449
• ITU-T V-Series
• I.430
• I.431
• PDH
• SONET/SDH
• PON
• OTN
• DSL
• IEEE 802.3
• IEEE 802.11
• IEEE 802.15
• IEEE 802.16
• IEEE 1394
• ITU-T G.hn PHY
• USB
• Bluetooth
• RS-232
• RS-449
• v
• t
• e [1]

The **Open Systems Interconnection model** (OSI) is a conceptual model that characterizes and standardizes the internal functions of a communication system by partitioning it into abstraction layers. The model is a product of the Open Systems Interconnection project at the International Organization for Standardization (ISO), maintained by the identification ISO/IEC 7498-1.

The model groups communication functions into seven logical layers. A layer serves the layer above it and is served by the layer below it. For example, a layer that provides error-free communications across a network provides the path needed by applications above it, while it calls the next lower layer to send and receive packets that make up the contents of that path. Two instances at one layer are connected by a horizontal connection on that layer.

History

Work on a layered model of network architecture was started and the International Organization for Standardization (ISO) began to develop its OSI framework architecture. OSI had two major components: an *abstract model* of networking, called the Basic Reference Model or seven-layer model, and a set of specific protocols.

The concept of a seven-layer model was provided by the work of Charles

Communication in the OSI-Model (example with layers 3 to 5)

Bachman, Honeywell Information Services. Various aspects of OSI design evolved from experiences with the ARPANET, the fledgling Internet, NPLNET, EIN, CYCLADES network and the work in IFIP WG6.1. The new design was documented in ISO 7498 and its various addenda. In this model, a networking system was divided into layers. Within each layer, one or more entities implement its functionality. Each entity interacted directly only with the layer immediately beneath it, and provided facilities for use by the layer above it.

Protocols enabled an entity in one host to interact with a corresponding entity at the same layer in another host. Service definitions abstractly described the functionality provided to an (N)-layer by an (N-1) layer, where N was one of the seven layers of protocols operating in the local host.

The OSI standards documents are available from the ITU-T as the X.200-series of recommendations.[2] Some of the protocol specifications were also available as part of the ITU-T X series. The equivalent ISO and ISO/IEC standards for the OSI model were available from ISO, but only some of them without fees.
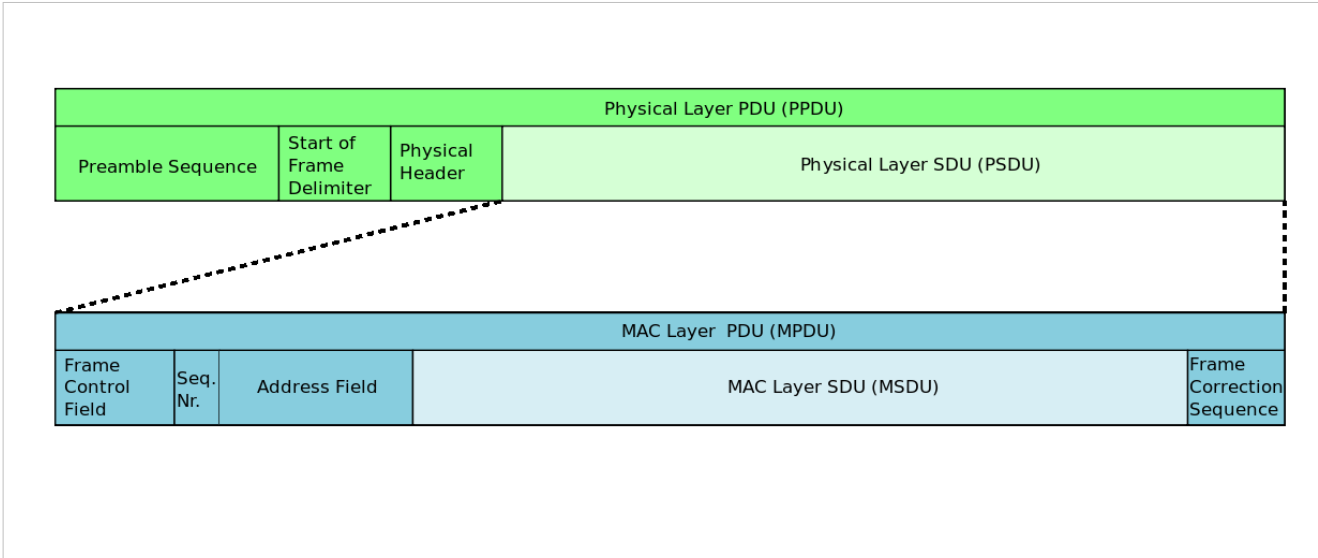
Description of OSI layers

According to recommendation X.200, there are seven layers, labeled 1 to 7, with layer 1 at the bottom.
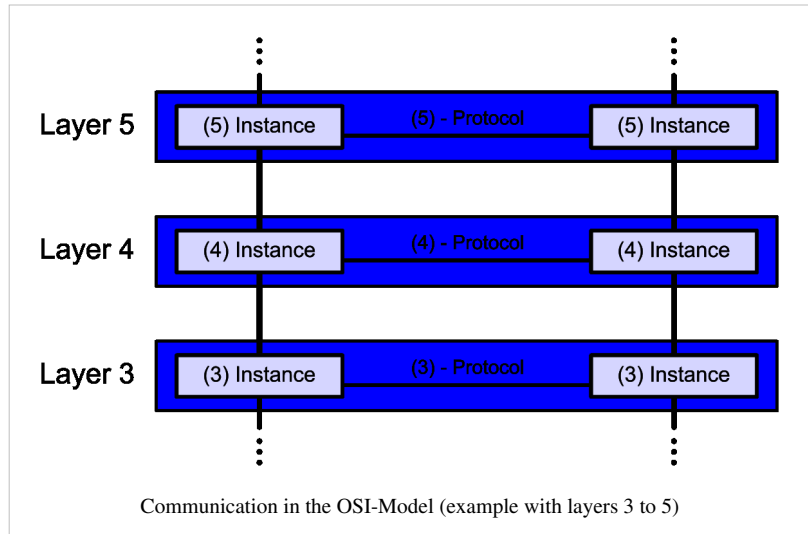
OSI Model			
	Data unit	Layer	Function
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation, encryption and decryption, convert machine dependent data to machine independent data
		5. Session	Interhost communication, managing sessions between applications
	Segments	4. Transport	Reliable delivery of packets between points on a network.
Media layers	Packet/Datagram	3. Network	Addressing, routing and (not necessarily reliable) delivery of datagrams between points on a network.
	Bit/Frame	2. Data link	A reliable direct point-to-point data connection.
	Bit	1. Physical	A (not necessarily reliable) direct point-to-point data connection.

At each level, two entities (layer-N peers) exchange protocol data units (PDUs) by means of a layer-N protocol. A service data unit (SDU) is the payload of a PDU, transmitted unchanged to a peer entity.

The SDU is a unit of data that has been passed down from an OSI layer to the next lower layer, and which the lower layer encapsulates into a PDU. Layer N-1 adds headers or footers, or both, to the SDU, composing a PDU of layer N-1. The added headers or footers make it possible to get the data from a source to a destination. The PDU at a layer N becomes the SDU of layer N-1.

Physical Layer PDU (PPDU)			
Preamble Sequence	Start of Frame Delimiter	Physical Header	Physical Layer SDU (PSDU)

MAC Layer PDU (MPDU)				
Frame Control Field	Seq. Nr.	Address Field	MAC Layer SDU (MSDU)	Frame Correction Sequence

Some orthogonal aspects, such as management and security, involve every layer.

Security services are not related to a specific layer: they can be related by a number of layers, as defined by ITU-T X.800 Recommendation.

These services are aimed to improve the CIA triad (confidentiality, integrity, and availability) of transmitted data. In practice, the availability of communication service is determined by the interaction between network design and network management protocols. Appropriate choices for both of these are needed to protect against denial of service.[citation needed]

Layer 1: physical layer

The physical layer has the following major functions:

- it defines the electrical and physical specifications of the data connection. It defines the relationship between a device and a physical transmission medium (e.g., a copper or fiber optical cable). This includes the layout of pins, voltages, line impedance, cable specifications, signal timing, hubs, repeaters, network adapters, host bus adapters (HBA used in storage area networks) and more.
- it defines the protocol to establish and terminate a connection between two directly connected nodes over a communications medium.
- it may define the protocol for flow control.
- it defines a protocol for the provision of a (not necessarily reliable) connection between two directly connected nodes, and the modulation or conversion between the representation of digital data in user equipment and the corresponding signals transmitted over the physical communications channel. This channel can involve physical cabling (such as copper and optical fiber) or a wireless radio link.

The physical layer of Parallel SCSI operates in this layer, as do the physical layers of Ethernet and other local-area networks, such as Token Ring, FDDI, ITU-T G.hn, and IEEE 802.11, as well as personal area networks such as Bluetooth and IEEE 802.15.4.

Layer 2: data link layer

The data link layer provides a reliable link between two directly connected nodes, by detecting and possibly correcting errors that may occur in the physical layer.

The Point-to-Point Protocol (PPP) is an example of a data link layer in the TCP/IP protocol stack.

The ITU-T G.hn standard, which provides high-speed local area networking over existing wires (power lines, phone lines and coaxial cables), includes a complete data link layer which provides both error correction and flow control by means of a selective-repeat sliding-window protocol.

Layer 3: network layer

The network layer provides the functional and procedural means of transferring variable length data sequences (called datagrams) from one node to another connected to the same *network*. A network is a medium to which many nodes can be connected, on which every node has an *address* and which permits nodes connected to it to transfer messages to other nodes connected to it by merely providing the content of a message and the address of the destination node and letting the network find the way to deliver ("route") the message to the destination node. In addition to message routing, the network may (or may not) implement message delivery by splitting the message into several fragments, delivering each fragment by a separate route and reassembling the fragments, report delivery errors, etc.

Datagram delivery at the network layer is *not* guaranteed to be *reliable*.

A number of layer-management protocols, a function defined in the *management annex*, ISO 7498/4, belong to the network layer. These include routing protocols, multicast group management, network-layer information and error, and network-layer address assignment. It is the function of the payload that makes these belong to the network layer, not the protocol that carries them.

Layer 4: transport layer

The transport layer provides the *reliable* sending of data packets between nodes (with addresses) located on a network, providing reliable data transfer services to the upper layers.

An example of a transport-layer protocol in the standard Internet protocol stack is TCP, usually built on top of the IP protocol.

The transport layer controls the reliability of a given link through flow control, segmentation/desegmentation, and error control. Some protocols are state- and connection-oriented. This means that the transport layer can keep track of the segments and retransmit those that fail. The transport layer also provides the acknowledgement of the successful data transmission and sends the next data if no errors occurred. The transport layer creates packets out of the message received from the application layer. Packetizing is a process of dividing the long message into smaller messages.

OSI defines five classes of connection-mode transport protocols ranging from class 0 (which is also known as TP0 and provides the least features) to class 4 (TP4, designed for less reliable networks, similar to the Internet). Class 0 contains no error recovery, and was designed for use on network layers that provide error-free connections. Class 4 is closest to TCP, although TCP contains functions, such as the graceful close, which OSI assigns to the session layer. Also, all OSI TP connection-mode protocol classes provide expedited data and preservation of record boundaries. Detailed characteristics of TP0-4 classes are shown in the following table:

Feature Name	TP0	TP1	TP2	TP3	TP4
Connection-oriented network	Yes	Yes	Yes	Yes	Yes
Connectionless network	No	No	No	No	Yes
Concatenation and separation	No	Yes	Yes	Yes	Yes
Segmentation and reassembly	Yes	Yes	Yes	Yes	Yes
Error recovery	No	Yes	Yes	Yes	Yes
Reinitiate connection (if an excessive number of PDUs are unacknowledged)	No	Yes	No	Yes	No
Multiplexing and demultiplexing over a single virtual circuit	No	No	Yes	Yes	Yes
Explicit flow control	No	No	Yes	Yes	Yes
Retransmission on timeout	No	No	No	No	Yes
Reliable transport service	No	Yes	No	Yes	Yes

An easy way to visualize the transport layer is to compare it with a post office, which deals with the dispatch and classification of mail and parcels sent. Do remember, however, that a post office manages the outer envelope of mail. Higher layers may have the equivalent of double envelopes, such as cryptographic presentation services that can be read by the addressee only. Roughly speaking, tunneling protocols operate at the transport layer, such as carrying non-IP protocols such as IBM's SNA or Novell's IPX over an IP network, or end-to-end encryption with IPsec. While Generic Routing Encapsulation (GRE) might seem to be a network-layer protocol, if the encapsulation of the payload takes place only at endpoint, GRE becomes closer to a transport protocol that uses IP headers but contains complete frames or packets to deliver to an endpoint. L2TP carries PPP frames inside transport packet.

Although not developed under the OSI Reference Model and not strictly conforming to the OSI definition of the transport layer, the Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP) of the Internet Protocol Suite are commonly categorized as layer-4 protocols within OSI.

Layer 5: session layer

The session layer controls the dialogues (connections) between computers. It establishes, manages and terminates the connections between the local and remote application. It provides for full-duplex, half-duplex, or simplex operation, and establishes checkpointing, adjournment, termination, and restart procedures. The OSI model made this layer responsible for graceful close of sessions, which is a property of the Transmission Control Protocol, and also for session checkpointing and recovery, which is not usually used in the Internet Protocol Suite. The session layer is commonly implemented explicitly in application environments that use remote procedure calls.

Layer 6: presentation layer

The presentation layer establishes context between application-layer entities, in which the application-layer entities may use different syntax and semantics if the presentation service provides a mapping between them. If a mapping is available, presentation service data units are encapsulated into session protocol data units, and passed down the TCP/IP stack.

This layer provides independence from data representation (e.g., encryption) by translating between application and network formats. The presentation layer transforms data into the form that the application accepts. This layer formats and encrypts data to be sent across a network. It is sometimes called the syntax layer.

The original presentation structure used the Basic Encoding Rules of Abstract Syntax Notation One (ASN.1), with capabilities such as converting an EBCDIC-coded text file to an ASCII-coded file, or serialization of objects and other data structures from and to XML.

Layer 7: application layer

The application layer is the OSI layer closest to the end user, which means both the OSI application layer and the user interact directly with the software application. This layer interacts with software applications that implement a communicating component. Such application programs fall outside the scope of the OSI model. Application-layer functions typically include identifying communication partners, determining resource availability, and synchronizing communication. When identifying communication partners, the application layer determines the identity and availability of communication partners for an application with data to transmit. When determining resource availability, the application layer must decide whether sufficient network or the requested communication exists. In synchronizing communication, all communication between applications requires cooperation that is managed by the application layer. Some examples of application-layer implementations also include:

- On OSI stack:

  - FTAM File Transfer and Access Management Protocol
  - X.400 Mail
  - Common Management Information Protocol (CMIP)
- On TCP/IP stack:

  - Hypertext Transfer Protocol (HTTP),
  - File Transfer Protocol (FTP),
  - Simple Mail Transfer Protocol (SMTP)
  - Simple Network Management Protocol (SNMP)...

Cross-layer functions

There are some functions or services that are not tied to a given layer, but they can affect more than one layer. Examples include the following:

- Security service (telecommunication)[] as defined by ITU-T X.800 recommendation.
- Management functions, i.e. functions that permit to configure, instantiate, monitor, terminate the communications of two or more entities: there is a specific application-layer protocol, common management information protocol (CMIP) and its corresponding service, common management information service (CMIS), they need to interact with every layer in order to deal with their instances.
- Multiprotocol Label Switching (MPLS) operates at an OSI-model layer that is generally considered to lie between traditional definitions of layer 2 (data link layer) and layer 3 (network layer), and thus is often referred to as a "layer-2.5" protocol. It was designed to provide a unified data-carrying service for both circuit-based clients and packet-switching clients which provide a datagram-based service model. It can be used to carry many different kinds of traffic, including IP packets, as well as native ATM, SONET, and Ethernet frames.
- ARP is used to translate IPv4 addresses (OSI layer 3) into Ethernet MAC addresses (OSI layer 2).

Interfaces

Neither the OSI Reference Model nor OSI protocols specify any programming interfaces, other than as deliberately abstract service specifications. Protocol specifications precisely define the interfaces between different computers, but the software interfaces inside computers, known as network sockets are implementation-specific.

For example Microsoft Windows' Winsock, and Unix's Berkeley sockets and System V Transport Layer Interface, are interfaces between applications (layer 5 and above) and the transport (layer 4). NDIS and ODI are interfaces between the media (layer 2) and the network protocol (layer 3).

Interface standards, except for the physical layer to media, are approximate implementations of OSI service specifications.

Examples

Layer		OSI protocols	TCP/IP protocols	Signaling System 7[3]	AppleTalk	IPX	SNA	UMTS	Misc. examples
#	Name								
7	Application	FTAM, X.400, X.500, DAP, ROSE, RTSE, ACSE[4] CMIP[5]	NNTP, SIP, SSI, DNS, FTP, Gopher, HTTP, NFS, NTP, DHCP, SMPP, SMTP, SNMP, Telnet, BGP, FCIP	INAP, MAP, TCAP, ISUP, TUP	AFP, ZIP, RTMP, NBP	SAP	APPC		HL7, Modbus
6	Presentation	ISO/IEC 8823, X.226, ISO/IEC 9576-1, X.236	MIME, SSL, TLS, XDR		AFP				TDI, ASCII, EBCDIC, MIDI, MPEG
5	Session	ISO/IEC 8327, X.225, ISO/IEC 9548-1, X.235	Sockets. Session establishment in TCP, RTP, PPTP		ASP, ADSP, PAP	NWLink	DLC?		Named pipes, NetBIOS, SAP, half duplex, full duplex, simplex, RPC, SOCKS
4	Transport	ISO/IEC 8073, TP0, TP1, TP2, TP3, TP4 (X.224), ISO/IEC 8602, X.234	TCP, UDP, SCTP, DCCP			DDP, SPX			NBF
3	Network	ISO/IEC 8208, X.25 (Packet-LaISO/IEC 8878, X.223, ISO/IEC 8473-1, CLNP X.233.	IP, IPsec, ICMP, IGMP, OSPF, RIP	SCCP, MTP	ATP (TokenTalk or EtherTalk)	IPX		RRC (Radio Resource Control) and BMC (Broadcast/Multicast Control)	NBF, Q.931, NDP, ARP (maps layer 3 to layer 2 address), IS-IS
2	Data link layer	ISO/IEC 7666, X.25 (LAPB), Token Bus, X.222, ISO/IEC 8802-2 LLC Type 1 and 2[6]	PPP, SBTV, SLIP	MTP, Q.710	LocalTalk, AppleTalk Remote Access, PPP	IEEE 802.3 framing, Ethernet II framing	SDLC	Packet Data Convergence Protocol (PDCP),[7] LLC (Logical Link Control), MAC (Media Access Control)	802.3 (Ethernet), 802.11a/b/g/n MAC/LLC, 802.1Q (VLAN), ATM, HDP, FDDI, Fibre Channel, Frame Relay, HDLC, ISL, PPP, Q.921, Token Ring, CDP, ITU-T G.hn DLL CRC, Bit stuffing, ARQ, Data Over Cable Service Interface Specification (DOCSIS), interface bonding

| 1 | Physical | X.25 (X.21bis, EIA/TIA-232, EIA/TIA-449, EIA-530, G.703) | | MTP, Q.710 | RS-232, RS-422, STP, PhoneNet | | Twinax | UMTS Physical layer or L1 | RS-232, Full duplex, RJ45, V.35, V.34, I.430, I.431, T1, E1, 10BASE-T, 100BASE-TX, 1000BASE-T, POTS, SONET, SDH, DSL, 802.11a/b/g/n PHY, ITU-T G.hn PHY, Controller Area Network, Data Over Cable Service Interface Specification (DOCSIS), DWDM |

Comparison with TCP/IP model

In the TCP/IP model of the Internet, protocols are deliberately not as rigidly designed into strict layers as in the OSI model.[8] RFC 3439 contains a section entitled "Layering considered harmful".[9] However, TCP/IP does recognize four broad layers of functionality which are derived from the operating scope of their contained protocols: the scope of the software application; the end-to-end transport connection; the internetworking range; and the scope of the direct links to other nodes on the local network.

Even though the concept is different from the OSI model, these layers are nevertheless often compared with the OSI layering scheme in the following way:

* The Internet application layer includes the OSI application layer, presentation layer, and most of the session layer.
* Its end-to-end transport layer includes the graceful close function of the OSI session layer as well as the OSI transport layer.
* The internetworking layer (Internet layer) is a subset of the OSI network layer (see above)
* The link layer includes the OSI data link and physical layers, as well as parts of OSI's network layer.

These comparisons are based on the original seven-layer protocol model as defined in ISO 7498, rather than refinements in such things as the internal organization of the network layer document.[citation needed]

The presumably strict peer layering of the OSI model as it is usually described does not present contradictions in TCP/IP, as it is permissible that protocol usage does not follow the hierarchy implied in a layered model. Such examples exist in some routing protocols (e.g., OSPF), or in the description of tunneling protocols, which provide a link layer for an application, although the tunnel host protocol might well be a transport or even an application-layer protocol in its own right.[citation needed]

References

[1] http://en.wikipedia.org/w/index.php?title=Template:OSIstack&action=edit

[2] ITU-T X-Series Recommendations (http://www.itu.int/rec/T-REC-X/en)

[3] ITU-T Recommendation Q.1400 (03/1993) (http://www.itu.int/rec/T-REC-Q.1400/en/), *Architecture framework for the development of signaling and OA&M protocols using OSI concepts*, pp 4, 7.

[4] ITU Rec. X.227 (ISO 8650), X.217 (ISO 8649)

[5] X.700 series of recommendations from the ITU-T (in particular X.711), and ISO 9596

[6] CISCO Cisco Systems, Inc. Internetworking Technology Handbook OSI Model Physical layer (http://www.cisco.com/en/US/docs/internetworking/technology/handbook/Intro-to-Internet.html#wp1020669)

[7] 3GPP TS 36.300 : E-UTRA and E-UTRAN Overall Description, Stage 2, Release 11 (http://www.3gpp.org/ftp/Specs/html-info/36300.htm)

[8] RFC 3439

[9] http://tools.ietf.org/html/rfc3439#section-3

External links

- ISO/IEC standard 7498-1:1994 (http://standards.iso.org/ittf/PubliclyAvailableStandards/s020269_ISO_IEC_7498-1_1994(E).zip) (PDF document inside ZIP archive) (requires HTTP cookies in order to accept licence agreement)

- ITU-T X.200 (the same contents as from ISO) (http://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-X.200-199407-I!!PDF-E&type=items)

- The ISO OSI Reference Model , Beluga graph of data units and groups of layers (http://infchg.appspot.com/usr?at=1263939371)

- Zimmermann, Hubert (April 1980). "OSI Reference Model — The ISO Model of Architecture for Open Systems Interconnection". *IEEE Transactions on Communications* **28** (4): 425–432. doi: 10.1109/TCOM.1980.1094702 (http://dx.doi.org/10.1109/TCOM.1980.1094702). CiteSeerX: 10.1.1.136.9497 (http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.136.9497).

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Ghostalker, Giftlite, Gilliam, Ginsuloft, GlassCobra, Glenn, Goodnightmush, GorillaWarfare, Graeme Bartlett, Grafen, Graham.rellinger, GreYFoXGTi, Grendelkhan, Grubber, Gsl, Gurchzilla, Guy Harris, Gwernol, Gökhan, H2g2bob, H34d, HMGb, Haakon, Hadal, HamatoKameko, Happysailor, HarisM, Hatch68, Hcberkowitz, Hdante, Helix84, Hellomarius, Henrikholm, Herbee, Heron, Hes Nikke, Hetar, HexaChord, Hgerstung, Hiddekel, Highpriority, Honeyman, I dream of horses, IMSoP, IReceivedDeathThreats, Iambk, Iambossatghari, Ideoplex, Ifroggie, Ilario, Immunize, Inkhorn, Inkling, Insineratehymn, Intgr, Inversetime, InvisibleK, Inwind, Iridescent, Irnavash, IronGargoyle, Ishikawa Minoru, Island Monkey, Isofox, Isthisthingworking, Itpastorn, Itusg15q4user, Iviney, J.delanoy, JMatthews, JV Smithy, Jake Wartenberg, Jakuzem, JamesBWatson, Jannetta, Jatinsinha, Jauerback, Jchristn, Jcw69, Jdrrmk, JeTataMe, Jeanjour, Jeff G., Jeffrey Mall, Jessemerriman, Jetekus, Jhilving, Jianhui67, JidGom, Jim1138, Jimw338, 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