# Oracle® Database Appliance Licensing Information User Manual





Oracle Database Appliance Licensing Information User Manual, Release 19.27

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### **Preface**

This document, which is part of the Program Documentation under the terms of your Oracle licensing agreement, is intended to help you understand the features, functionality, and options available for Oracle Programs.

If you have a question about your licensing needs, then contact your Oracle sales representative or the License Management Services representative at <a href="http://www.oracle.com/us/corporate/license-management-services/index.html">http://www.oracle.com/us/corporate/license-management-services/index.html</a>. You can also refer to the resources listed in "Related Documents" for more information.

- Audience
- Documentation Accessibility
- · Related Documents
- Conventions

### **Audience**

This book is intended for all purchasers of Oracle Database Appliance.

## **Documentation Accessibility**

For information about Oracle's commitment to accessibility, visit the Oracle Accessibility Program website at http://www.oracle.com/pls/topic/lookup?ctx=acc&id=docacc.

#### **Access to Oracle Support**

Oracle customer access to and use of Oracle support services will be pursuant to the terms and conditions specified in their Oracle order for the applicable services.

### **Related Documents**

For more information about Oracle Database Appliance, go to http://www.oracle.com/goto/oda/docs and click the appropriate release.

For more information about using Oracle Database, go to http://docs.oracle.com/database/ and select the database release from the menu.

For more information about Oracle Integrated Lights Out Manager 3.2, see https://docs.oracle.com/cd/E37444 01/.

For more details about other Oracle products that are mentioned in Oracle Database Appliance documentation, see the Oracle Documentation home page at http://docs.oracle.com.

## Conventions

The following text conventions are used in this document:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
italic	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
monospace	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.



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## Introduction

This Licensing Information document is a part of the product or program documentation under the terms of your Oracle license agreement and is intended to help you understand the program editions, entitlements, restrictions, prerequisites, special license rights, and/or separately licensed third party technology terms associated with the Oracle software program(s) covered by this document (the "Program(s)").

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## Oracle Database Appliance Licensing Overview

This chapter provides an overview of the licensing process for each hardware platform.

#### Topics:

- About Licensing
   Oracle Database Appliance provides capacity-on-demand licensing.
- CPUs and Core Count
   Review this section for information about core license options for your Oracle Database
   Appliance hardware.
- Oracle Database Appliance KVM Hard Partitioning Compliance
   Review this section for information about Oracle Database Appliance KVM Hard Partitioning compliance.

## **About Licensing**

Oracle Database Appliance provides capacity-on-demand licensing.

Capacity-on-demand (CoD) refers to an Oracle Database Appliance server that has a subset of its cores turned off so that the Oracle Database Enterprise Edition or Oracle Database Standard Edition 2 software license cost can be reduced. The number of cores can be reduced before or after the deployment. The number of active cores can be increased at a later time, when more capacity is needed. Oracle Database is licensed separately. Refer to Database Licensing Information User Manual for additional information.

When you add your hardware Support Identifier (SI) for Oracle Database Appliance to your My Oracle Support account, you establish a license for all the cores on your system. Oracle Database Appliance models can be deployed as bare metal systems or KVM-based virtualized systems. Both platform types offer capacity-on-demand licensing.

With bare-metal installations, you disable cores that you do not intend Oracle Database to use:

For Oracle Database Appliance X11, X10, X9-2S, X9-2L, X9-2-HA, X8-2S, X8-2M, X8-2-HA, X7-2S, X7-2M, X7-2-HA: Issue the command odacli modify-cpucore to set the low water mark and to increase the cores.

Chapter three explains how to obtain a licensing key and record your initial license requirements with My Oracle Support. It also explains how to change the licensed core count, if necessary, later. Chapter three is appropriate for bare metal installations where your license covers the cores that you are using for Oracle Database.

Chapter four contains information about the third-party products that are included with Oracle Database Appliance.

If you use the Integrated Oracle Data Guard feature only, then you **do not** require a separate Oracle Active Data Guard license.

## About License Options for Oracle Database Standard Edition 2 on Oracle Database Appliance

For the purposes of licensing Oracle Database Standard Edition 2 on Oracle Database Appliance running multi-chip modules, where each chip in a multi-chip module is counted as an occupied socket for licensing purposes, you may exceed the 2 sockets per server limit. Oracle Database Standard Edition 2 requires one processor license for every 8 enabled cores on Oracle Database Appliance running multi-chip modules. If the number of enabled cores is not divisible by 8, the quotient must be rounded up to the nearest whole number to determine the number of Oracle Database Standard Edition 2 processor licenses required.



The minimum licenses when licensing by SE2 Named User Plus (NUP) metric are 10 NUP licenses per server.

### CPUs and Core Count

Review this section for information about core license options for your Oracle Database Appliance hardware.

- Oracle Database Appliance X11-HA has 2 servers, each with 2 CPUs of 32 cores each.
   When you deploy Oracle Database Appliance X11-HA, all 128 cores (64 cores in each server) are active with hyper-threading enabled by default.
- Oracle Database Appliance X11-L contains 2 CPUs with 32 cores for a total of 64 cores.
   When you deploy Oracle Database Appliance X11-L, all 64 cores are active with hyperthreading enabled by default.
- Oracle Database Appliance X11-S contains 1 CPU with 32 cores. When you deploy Oracle Database Appliance X11-S, all 32 cores are active with hyper-threading enabled by default.
- Oracle Database Appliance X10-HA has 2 servers, each with 2 CPUs of 32 cores each.
   When you deploy Oracle Database Appliance X10-HA, all 128 cores (64 cores in each server) are active with hyper-threading enabled by default.
- Oracle Database Appliance X10-L contains 2 CPUs with 32 cores for a total of 64 cores.
   When you deploy Oracle Database Appliance X10-L, all 64 cores are active with hyperthreading enabled by default.
- Oracle Database Appliance X10-S contains 1 CPU with 32 cores. When you deploy Oracle
  Database Appliance X10-S, all 32 cores are active with hyper-threading enabled by
  default.
- Oracle Database Appliance X9-2-HA has 2 servers, each with 2 CPUs of 16 cores each.
   When you deploy Oracle Database Appliance X9-2-HA, all 64 cores (32 cores in each server) are active with hyper-threading enabled by default.



- Oracle Database Appliance X9-2L contains 2 CPUs with 16 cores for a total of 32 cores.
   When you deploy Oracle Database Appliance X9-2L, all 32 cores are active with hyperthreading enabled by default.
- Oracle Database Appliance X9-2S contains 1 CPU with 16 cores. When you deploy Oracle
  Database Appliance X9-2S, all 16 cores are active with hyper-threading enabled by
  default.
- Oracle Database Appliance X8-2-HA has 2 servers, each with 2 CPUs of 16 cores each.
   When you deploy Oracle Database Appliance X8-2-HA, all 64 cores (32 cores in each server) are active with hyper-threading enabled by default.
- Oracle Database Appliance X8-2M contains 2 CPUs with 16 cores for a total of 32 cores.
   When you deploy Oracle Database Appliance X8-2M, all 32 cores are active with hyperthreading enabled by default.
- Oracle Database Appliance X8-2S contains 1 CPU with 16 cores. When you deploy Oracle
  Database Appliance X8-2S, all 16 cores are active with hyper-threading enabled by
  default.
- Oracle Database Appliance X7-2-HA has 2 servers, each with 2 CPUs of 18 cores each.
   When you deploy Oracle Database Appliance X7-2-HA, all 72 cores (36 cores in each server) are active with hyper-threading enabled by default.
- Oracle Database Appliance X7-2M contains 2 CPUs with 18 cores for a total of 36 cores.
   When you deploy Oracle Database Appliance X7-2M, all 36 cores are active with hyperthreading enabled by default.
- Oracle Database Appliance X7-2S contains 1 CPU with 10 cores. When you deploy Oracle
  Database Appliance X7-2S, all 10 cores are active with hyper-threading enabled by
  default.

Oracle Database Appliance bare metal licensing is determined by the number of enabled cores that you have on your system. The capacity-on-demand licensing feature enables you to change the enabled core count as your system resource needs change.

Initialize the number of licensed cores to the level currently required by your applications. Each server node has the same number of active cores. Later, increase the licensed core count as your applications require more capacity. Change the number of licensed cores by obtaining and applying a core key to configure your appliance, using the tables for your Oracle Database Appliance platform.

#### Oracle Database Appliance X11-HA Licensed Core Licensing Options

The table provides an example of how the licensed cores for each node of an Oracle Database Appliance X11-HA relate to active cores for Oracle RAC and Oracle Enterprise Edition and active cores for Oracle RAC One Node.

Table 2-1 Example of Bare Metal License Options for Oracle Database Appliance X11-HA Systems

Licensed Cores for Each Node (X11-HA Only)	Active Cores for Oracle RAC and Oracle Enterprise Edition (X11-HA Only)	Active Cores for Oracle RAC One Node (X11-HA Only)
2	4	2
4	8	4
6	12	6
8	16	8



Table 2-1 (Cont.) Example of Bare Metal License Options for Oracle Database Appliance X11-HA Systems

Licensed Cores for Each Node (X11-HA Only)	Active Cores for Oracle RAC and Oracle Enterprise Edition (X11-HA Only)	Active Cores for Oracle RAC One Node (X11-HA Only)
10	20	10
12	24	12
14	28	14
16	32	16
18	36	18
20	40	20
22	44	22
24	48	24
26	52	26
28	56	28
30	60	30
32	64	32

Oracle Database Appliance X11-L and X11-S Licensed Core Licensing Options

Table 2-2 Bare Metal License Options for all Oracle Database Appliance X11-L and X11-S Systems

Licensed Cores for Single Node (X11-S)	Licensed Cores for Single Node (X11-L)
2	2
4	4
6	6
8	8
10	10
12	12
14	14
16	16
Not applicable	18
Not applicable	20
Not applicable	22
Not applicable	24
Not applicable	26
Not applicable	28
Not applicable	30
Not applicable	32



#### Oracle Database Appliance X10-HA Licensed Core Licensing Options

The table provides an example of how the licensed cores for each node of an Oracle Database Appliance X10-HA relate to active cores for Oracle RAC and Oracle Enterprise Edition and active cores for Oracle RAC One Node.

Table 2-3 Example of Bare Metal License Options for Oracle Database Appliance X10-HA Systems

Licensed Cores for Each Node (X10-HA Only)	Active Cores for Oracle RAC and Oracle Enterprise Edition (X10-HA Only)	Active Cores for Oracle RAC One Node (X10-HA Only)
2	4	2
4	8	4
6	12	6
8	16	8
10	20	10
12	24	12
14	28	14
16	32	16
18	36	18
20	40	20
22	44	22
24	48	24
26	52	26
28	56	28
30	60	30
32	64	32

Oracle Database Appliance X10-L and X10-S Licensed Core Licensing Options

Table 2-4 Bare Metal License Options for all Oracle Database Appliance X10-L and X10-S Systems

Licensed Cores for Single Node (X10-S)	Licensed Cores for Single Node (X10-L)
2	2
4	4
6	6
8	8
10	10
12	12
14	14
16	16
Not applicable	18
Not applicable	20



Table 2-4 (Cont.) Bare Metal License Options for all Oracle Database Appliance X10-L and X10-S Systems

Licensed Cores for Single Node (X10-S)	Licensed Cores for Single Node (X10-L)
Not applicable	22
Not applicable	24
Not applicable	26
Not applicable	28
Not applicable	30
Not applicable	32

#### Oracle Database Appliance X9-2-HA Licensed Core Licensing Options

The table provides an example of how the licensed cores for each node of an Oracle Database Appliance X9-2-HA relate to active cores for Oracle RAC and Oracle Enterprise Edition and active cores for Oracle RAC One Node.

Table 2-5 Example of Bare Metal License Options for Oracle Database Appliance X9-2-HA Systems

Licensed Cores for Each Node (X9-2-HA Only)	Active Cores for Oracle RAC and Oracle Enterprise Edition (X9-2-HA Only)	Active Cores for Oracle RAC One Node (X9-2-HA Only)
2	4	2
4	8	4
6	12	6
8	16	8
10	20	10
12	24	12
14	28	14
16	32	16
18	36	18
20	40	20
22	44	22
24	48	24
26	52	26
28	56	28
30	60	30
32	64	32



Oracle Database Appliance X9-2L and X9-2S Licensed Core Licensing Options

Table 2-6 Bare Metal License Options for all Oracle Database Appliance X9-2L and X9-2S Systems

Licensed Cores for Single Node (X9-2S)	Licensed Cores for Single Node (X9-2L)
2	2
4	4
6	6
8	8
10	10
12	12
14	14
16	16
Not applicable	18
Not applicable	20
Not applicable	22
Not applicable	24
Not applicable	26
Not applicable	28
Not applicable	30
Not applicable	32

#### Oracle Database Appliance X8-2-HA Licensed Core Licensing Options

The table provides an example of how the licensed cores for each node of an Oracle Database Appliance X8-2-HA relate to active cores for Oracle RAC and Oracle Enterprise Edition and active cores for Oracle RAC One Node.

Table 2-7 Example of Bare Metal License Options for Oracle Database Appliance X8-2-HA Systems

Licensed Cores for Each Node (X8-2-HA Only)	Active Cores for Oracle RAC and Oracle Enterprise Edition (X8-2-HA Only)	Active Cores for Oracle RAC One Node (X8-2-HA Only)
2	4	2
4	8	4
6	12	6
8	16	8
10	20	10
12	24	12
14	28	14
16	32	16
18	36	18
20	40	20



Table 2-7 (Cont.) Example of Bare Metal License Options for Oracle Database Appliance X8-2-HA Systems

Licensed Cores for Each Node (X8-2-HA Only)	Active Cores for Oracle RAC and Oracle Enterprise Edition (X8-2-HA Only)	Active Cores for Oracle RAC One Node (X8-2-HA Only)
22	44	22
24	48	24
26	52	26
28	56	28
30	60	30
32	64	32

Oracle Database Appliance X8-2M and X8-2S Licensed Core Licensing Options

Table 2-8 Bare Metal License Options for all Oracle Database Appliance X8-2M and X8-2S Systems

Licensed Cores for Single Node (X8-2S)	Licensed Cores for Single Node (X8-2M)
2	2
4	4
6	6
8	8
10	10
12	12
14	14
16	16
Not applicable	18
Not applicable	20
Not applicable	22
Not applicable	24
Not applicable	26
Not applicable	28
Not applicable	30
Not applicable	32

#### Oracle Database Appliance X7-2-HA Licensed Core Licensing Options

The table provides an example of how the licensed cores for each node of an Oracle Database Appliance X7-2-HA relate to active cores for Oracle RAC and Oracle Enterprise Edition and active cores for Oracle RAC One Node.

Table 2-9 Example of Bare Metal License Options for Oracle Database Appliance X7-2-HA Systems

Licensed Cores for Each Node (X7-2-HA Only)	Active Cores for Oracle RAC and Oracle Enterprise Edition (X7-2-HA Only)	Active Cores for Oracle RAC One Node (X7-2-HA Only)
2	4	2
4	8	4
6	12	6
8	16	8
10	20	10
12	24	12
14	28	14
16	32	16
18	36	18
20	40	20
22	44	22
24	48	24
26	52	26
28	56	28
30	60	30
32	64	32
34	68	34
36	72	36

**Oracle Database Appliance X7-2 Licensed Core Licensing Options** 

Table 2-10 Bare Metal License Options for all Oracle Database Appliance X7-2 Systems

Licensed Cores for Single Node (X7-2S)	Licensed Cores for Single Node (X7-2M)
2	2
4	4
6	6
8	8
10	10
Not applicable	12
Not applicable	14
Not applicable	16
Not applicable	18
Not applicable	20
Not applicable	22
Not applicable	24
Not applicable	26

Table 2-10 (Cont.) Bare Metal License Options for all Oracle Database Appliance X7-2 Systems

Licensed Cores for Single Node (X7-2S)	Licensed Cores for Single Node (X7-2M)
Not applicable	28
Not applicable	30
Not applicable	32
Not applicable	34
Not applicable	36

## Oracle Database Appliance KVM Hard Partitioning Compliance

Review this section for information about Oracle Database Appliance KVM Hard Partitioning compliance.

Oracle Database Appliance DB systems and application KVMs conform to Oracle Linux KVM Hard Partitioning requirements as specified in Hard Partitioning with Oracle Linux KVM:

https://www.oracle.com/a/ocom/docs/linux/ol-kvm-hard-partitioning.pdf

#### **Considerations for CPU Pool Subscription**

BM or VM CPU pools are used for management of CPU resources only. Database license requirements are determined by KVM Hard Partitioning only.

In a DB system with a shared or internal CPU pool, the cores are pinned based on the database shape selected for the DB system. For example, if you create a DB system with odb2, then you must license 2 cores.

In a DB system with a shared CPU pool, consider both undersubscription and oversubscription scenarios.

- Undersubscription: Consider a shared CPU pool with 8 cores. If you create a DB system with odb2 and another with odb4, then a total of 6 cores are used. So, although the shared CPU pool is undersubcribed, you must run the virsh command in each KVM or DB system to determine the pinned cores that need to be licensed. In this case, it is the same 8 cores visible to both DB systems.
- Oversubscription: Consider a shared CPU pool with 8 cores, and you create a DB system with odb4 and another with odb6. Although the shared CPU pool is oversubscribed, you must run the virsh command in each KVM or DB System to determine the pinned cores that need to be licensed. In this case, it is the same 8 cores visible to both DB systems.

Note that the same CPU pool subscription policy applies to shared CPU pools for application KVMs too.

#### Validating the CPUs for an Oracle Database Appliance DB System and Application KVM

You must run the <code>virsh</code> command for every DB system to identify the pinned vCPUs and CPU cores licensing requirements.



To validate that the CPUs for a virtual machine are pinned to a physical thread or core, run the following command:

```
# virsh --readonly vcpuinfo VM name --pretty
```

The following example illustrates how you can validate the CPUs for an Oracle Database Appliance DB System with the db shape odb2 that uses 2 cores (4 vCPUs):

1. Determine the VM Name by running this command:

```
# odacli describe-dbsystem -n dbs1 | grep "VM Name"
VM Name: x97f18b518
```

In this example, the DB System name is dbs1.

2. Run the virsh command to confirm that vCPUs are pinned to physical threads or cores for x97f18b518:

```
# virsh --readonly vcpuinfo x97f18b518 --pretty
              0
VCPU:
CPU:
              19
State:
             running
CPU time:
             79.3s
CPU Affinity: 19,24,55,60 (out of 72)
VCPU:
             1
             55
CPU:
             running
State:
CPU time:
             71.5s
CPU Affinity: 19,24,55,60 (out of 72)
VCPU:
             2
CPU:
             60
State:
             running
CPU time: 71.7s
CPU Affinity: 19,24,55,60 (out of 72)
             3
VCPU:
             24
CPU:
State:
             running
CPU time:
             73.1s
CPU Affinity: 19,24,55,60 (out of 72)
```

In this example, the pinned vCPUs are 19, 24, 55, and 60, out of 72.

## Capacity-On-Demand Licensing Information

This chapter provides capacity-on-demand licensing information for Oracle Database Appliance bare metal installations.

- Oracle Database Appliance Capacity-on-Demand Licensing
   Capacity-on-Demand software licensing enables you to deploy as few or as many
   processors in Oracle Database Appliance as your workload requires.
- Capacity-On-Demand Licensing for Oracle Database Appliance X11-S, X11-L, and X11-HA
  Review capacity-on-demand licensing for Oracle Database Appliance X11-S, X11-L, and
  X11-HA.
- Capacity-On-Demand Licensing for Oracle Database Appliance X10-S, X10-L, and X10-HA
  - Review capacity-on-demand licensing for Oracle Database Appliance X10-S, X10-L, and X10-HA.
- Capacity-On-Demand Licensing for Oracle Database Appliance X9-2S, X9-2L, and X9-2-HA
  - Review capacity-on-demand licensing for Oracle Database Appliance X9-2S, X9-2L, and X9-2-HA.
- Capacity-On-Demand Licensing for Oracle Database Appliance X8-2S, X8-2M, and X8-2-HA
  - Review capacity-on-demand licensing for Oracle Database Appliance X8-2S, X8-2M, and X8-2-HA.
- Capacity-On-Demand Licensing for Oracle Database Appliance X7-2S, X7-2M, and X7-2-HA
  - Review capacity-on-demand licensing for Oracle Database Appliance X7-2S, X7-2M, and X7-2-HA.

## Oracle Database Appliance Capacity-on-Demand Licensing

Capacity-on-Demand software licensing enables you to deploy as few or as many processors in Oracle Database Appliance as your workload requires.

Oracle Database Appliance's Capacity-on-Demand feature enables you to add more processor cores to scale up to increased system demands as you need to, without incurring the excessive costs and downtime usually associated with hardware upgrades. Additional cores are increased in 2-core increments.

#### **Oracle Database Appliance Scaling Capabilities**

The following table lists the scaling capacities for Oracle Database Appliance bare metal and virtualized platform deployments. The decision to use bare-metal or Oracle Database Appliance Virtualized Platform depends on your company policies and the benefits that each implementation offers your company.

**Table 3-1 Oracle Database Appliance Scaling Capacities** 

Oracle Database Appliance Platform	Minimum Number Processor Cores	Maximum Number Processor Cores
X10-S	2	32
X10-L	2	64
X10-HA	2	128
X9-2S	2	16
X9-2L	2	32
X9-2-HA	2	64
X8-2S	2	16
X8-2M	2	32
X8-2-HA	2	64
X7-2S	2	10
X7-2M	2	36
X7-2-HA	2	72
X6-2S	2	10
X6-2M	2	20
X6-2L	2	20
X6-2-HA	2	40
X5-2	2	72
X4-2	2	48

#### Applications Deployed on Oracle Database Appliance and Capacity-on-Demand

All Oracle products that are deployed on Oracle Database Appliance can take advantage of Capacity-on-Demand licensing.



For the procedure to set the CPU Core Count, see the *Oracle Database Appliance Deployment and User Guide* for your hardware model.

## Capacity-On-Demand Licensing for Oracle Database Appliance X11-S, X11-L, and X11-HA

Review capacity-on-demand licensing for Oracle Database Appliance X11-S, X11-L, and X11-HA.

For the procedure to set the CPU Core Count, see the *Oracle Database Appliance Deployment* and *User Guide* for your hardware model.

The following list describes the number of cores for each Oracle Database Appliance X11-S model:

- Oracle Database Appliance X11-S is a single server consisting of 32 cores.
- Oracle Database Appliance X11-L is a single server consisting of 64 cores.
- Oracle Database Appliance X11-HA consists of two servers. Each server has 64 cores, for a total of 128 cores.

By default, Oracle Database Appliance ships with all cores enabled. You can reduce the number of active cores before or after deployment. You can increase the number of active cores when additional capacity is needed. This is known as **capacity-on-demand**. Additional cores are increased in 2-core increments.

Rules and Restrictions for Setting CPU Core Count on Oracle Database Appliance X11-S, X11-L, and X11-HA Bare Metal Deployments

Review the following rules and restrictions before changing the CPU core count:

- You can change the CPU core count to a value that is a multiple of two between 2 and the
  maximum number of cores for the hardware model. For example, for X11-HA, between 2
  and 64 cores for each server for a maximum of 128 cores.
- If you change the CPU core count, then you can subsequently only increase the CPU core count.
- You should only change the CPU core count if you need less than the maximum number of cores.

For example, if you change the CPU core count to 8, then you can subsequently increase the CPU core count to a higher number (in increments of 2 cores), but you cannot decrease the CPU core count.

 If you want the maximum number of cores for each server (32 cores per server for X11-L and X11-HA), then use the default configuration. There is no need to set the CPU core count.



If you mistakenly followed the procedure to set your CPU core count to the maximum, thereby preventing you from subsequently decreasing your CPU core count, and the error is caught immediately, then contact Oracle Support.

## Capacity-On-Demand Licensing for Oracle Database Appliance X10-S, X10-L, and X10-HA

Review capacity-on-demand licensing for Oracle Database Appliance X10-S, X10-L, and X10-HA.

For the procedure to set the CPU Core Count, see the *Oracle Database Appliance Deployment* and *User Guide* for your hardware model.

The following list describes the number of cores for each Oracle Database Appliance X10-S model:

- Oracle Database Appliance X10-S is a single server consisting of 32 cores.
- Oracle Database Appliance X10-L is a single server consisting of 64 cores.



 Oracle Database Appliance X10-HA consists of two servers. Each server has 64 cores, for a total of 128 cores.

By default, Oracle Database Appliance ships with all cores enabled. You can reduce the number of active cores before or after deployment. You can increase the number of active cores when additional capacity is needed. This is known as **capacity-on-demand**. Additional cores are increased in 2-core increments.

Rules and Restrictions for Setting CPU Core Count on Oracle Database Appliance X10-S, X10-L, and X10-HA Bare Metal Deployments

Review the following rules and restrictions before changing the CPU core count:

- You can change the CPU core count to a value that is a multiple of two between 2 and the
  maximum number of cores for the hardware model. For example, for X10-HA, between 2
  and 64 cores for each server for a maximum of 128 cores.
- If you change the CPU core count, then you can subsequently only increase the CPU core count.
- You should only change the CPU core count if you need less than the maximum number of cores.

For example, if you change the CPU core count to 8, then you can subsequently increase the CPU core count to a higher number (in increments of 2 cores), but you cannot decrease the CPU core count.

 If you want the maximum number of cores for each server (32 cores per server for X10-L and X10-HA), then use the default configuration. There is no need to set the CPU core count.



If you mistakenly followed the procedure to set your CPU core count to the maximum, thereby preventing you from subsequently decreasing your CPU core count, and the error is caught immediately, then contact Oracle Support.

## Capacity-On-Demand Licensing for Oracle Database Appliance X9-2S, X9-2L, and X9-2-HA

Review capacity-on-demand licensing for Oracle Database Appliance X9-2S, X9-2L, and X9-2-  $\rm H\Delta$ 

For the procedure to set the CPU Core Count, see the *Oracle Database Appliance Deployment* and *User Guide* for your hardware model.

The following list describes the number of cores for each Oracle Database Appliance X9-2 model:

- Oracle Database Appliance X9-2S is a single server consisting of 16 cores.
- Oracle Database Appliance X9-2L is a single server consisting of 32 cores.
- Oracle Database Appliance X9-2-HA consists of two servers. Each server has 32 cores, for a total of 64 cores.

By default, Oracle Database Appliance ships with all cores enabled. You can reduce the number of active cores before or after deployment. You can increase the number of active



cores when additional capacity is needed. This is known as **capacity-on-demand**. Additional cores are increased in 2-core increments.

## Rules and Restrictions for Setting CPU Core Count on Oracle Database Appliance X9-2S, X9-2L, and X9-2-HA Bare Metal Deployments

Review the following rules and restrictions before changing the CPU core count:

- You can change the CPU core count to a value that is a multiple of two between 2 and the
  maximum number of cores for the hardware model. For example, for X9-2-HA, between 2
  and 32 cores for each server for a maximum of 64 cores.
- If you change the CPU core count, then you can subsequently only increase the CPU core count.
- You should only change the CPU core count if you need less than the maximum number of cores.

For example, if you change the CPU core count to 8, then you can subsequently increase the CPU core count to a higher number (in increments of 2 cores), but you cannot decrease the CPU core count.

 If you want the maximum number of cores for each server (32 cores per server for X9-2L and X9-2-HA), then use the default configuration. There is no need to set the CPU core count.



If you mistakenly followed the procedure to set your CPU core count to the maximum, thereby preventing you from subsequently decreasing your CPU core count, and the error is caught immediately, then contact Oracle Support.

## Capacity-On-Demand Licensing for Oracle Database Appliance X8-2S, X8-2M, and X8-2-HA

Review capacity-on-demand licensing for Oracle Database Appliance X8-2S, X8-2M, and X8-2-HA.

For the procedure to set the CPU Core Count, see the *Oracle Database Appliance Deployment* and *User Guide* for your hardware model.

The following list describes the number of cores for each Oracle Database Appliance X8-2 model:

- Oracle Database Appliance X8-2S is a single server consisting of 16 cores.
- Oracle Database Appliance X8-2M is a single server consisting of 32 cores.
- Oracle Database Appliance X8-2-HA consists of two servers. Each server has 32 cores, for a total of 64 cores.

By default, Oracle Database Appliance ships with all cores enabled. You can reduce the number of active cores before or after deployment. You can increase the number of active cores when additional capacity is needed. This is known as **capacity-on-demand**. Additional cores are increased in 2-core increments.



## Rules and Restrictions for Setting CPU Core Count on Oracle Database Appliance X8-2S, X8-2M, and X8-2-HA Bare Metal Deployments

Review the following rules and restrictions before changing the CPU core count:

- You can change the CPU core count to a value that is a multiple of two between 2 and the
  maximum number of cores for the hardware model. For example, for X8-2-HA, between 2
  and 32 cores for each server for a maximum of 64 cores.
- If you change the CPU core count, then you can subsequently only increase the CPU core count.
- You should only change the CPU core count if you need less than the maximum number of cores.

For example, if you change the CPU core count to 8, then you can subsequently increase the CPU core count to a higher number (in increments of 2 cores), but you cannot decrease the CPU core count.

 If you want the maximum number of cores for each server (32 cores per server for X8-2M and X8-2-HA), then use the default configuration. There is no need to set the CPU core count.



If you mistakenly followed the procedure to set your CPU core count to the maximum, thereby preventing you from subsequently decreasing your CPU core count, and the error is caught immediately, then contact Oracle Support.

## Capacity-On-Demand Licensing for Oracle Database Appliance X7-2S, X7-2M, and X7-2-HA

Review capacity-on-demand licensing for Oracle Database Appliance X7-2S, X7-2M, and X7-2-HA.

For the procedure to se the CPU Core Count, see the *Oracle Database Appliance Deployment* and *User Guide* for your hardware model.

The following list describes the number of cores for each Oracle Database Appliance X7-2 model:

- Oracle Database Appliance X7-2S is a single server consisting of 10 cores.
- Oracle Database Appliance X7-2M is a single server consisting of 36 cores.
- Oracle Database Appliance X7-2-HA consists of two servers. Each server has 36 cores, for a total of 72 cores.

By default, Oracle Database Appliance ships with all cores enabled. You can reduce the number of active cores before or after deployment. You can increase the number of active cores when additional capacity is needed. This is known as **capacity-on-demand**. Additional cores are increased in 2-core increments.

Rules and Restrictions for Setting CPU Core Count on Oracle Database Appliance X7-2S, X7-2M, and X7-2-HA Bare Metal Deployments

Review the following rules and restrictions before changing the CPU core count:



- You can change the CPU core count to a value that is a multiple of two between 2 and the maximum number of cores for the hardware model. For example, for X7-2-HA, between 2 and 36 cores for each server for a maximum of 72 cores.
- If you change the CPU core count, then you can subsequently only increase the CPU core count.
- You should only change the CPU core count if you need less than the maximum number of cores.

For example, if you change the CPU core count to 8, then you can subsequently increase the CPU core count to a higher number (in increments of 2 cores), but you cannot decrease the CPU core count.

 If you want the maximum number of cores for each server (36 cores per server for X7-2M and X7-2-HA), then use the default configuration. There is no need to set the CPU core count.



If you mistakenly followed the procedure to set your CPU core count to the maximum, thereby preventing you from subsequently decreasing your CPU core count, and the error is caught immediately, then contact Oracle Support.



4

## Third-Party Product Licenses for This Release

This chapter contains the licenses for the third-party products that are included with Oracle Database Appliance for this release.

- Oracle Database Third-Party Licensing Information
   Understand licensing information about third-party products used by Oracle Database.
- Other Third-Party Product Licenses
   Review other third-party product licenses for Oracle Database Appliance.
- Written Offer for Source Code

## Oracle Database Third-Party Licensing Information

Understand licensing information about third-party products used by Oracle Database.

Oracle Database Appliance includes Oracle Database19c. To view the licenses for these third-party products, refer to the release-specific *Oracle Database Licensing Information User Manual*.

#### **Related Topics**

Licensing Information User Manual Oracle Database 19c

## Other Third-Party Product Licenses

Review other third-party product licenses for Oracle Database Appliance.

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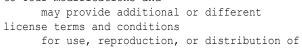
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### Authors of snowball arabic stemmer algorith
- Assem Chelli
- Abdelkrim Aries
- Lakhdar Benzahia
??????????????????????????????????????
nltk has dependencies on following libraries:
nltk needs "click"
"click" needs "importlib-metadata" "importlib-metadata" needs "typing-
extensions"
"typing-extensions" doesn't hav
any dependencies
"importlib-metadata" needs "zipp" "zipp" doesn't have any
dependencies
nltk needs "joblib"
"joblib" doesn't have any dependencies nltk needs "regex"
"regex" doesn't have any dependencies
nltk needs "tqdm"
"tqdm" doesn't have any dependencies
333333333333333333333333333333333333333

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package\_name: click
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Name: LAPJVsp

Files: scipy/sparse/csgraph/\_matching.pyx

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Name: Faddeeva

Files: scipy/special/Faddeeva.\*

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Name: ampgo

Files: benchmarks/benchmarks/
go\_benchmark\_functions/\*.py

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Functions for testing global optimizers,

forked from the AMPGO project,

https://code.google.com/archive/p/ampgo

Name: pybind11

Files: no source files are included, however

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included with every binary build of SciPy.

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"aggregate" if the compilation and its resulting copyright are not  $% \left( 1\right) =\left( 1\right) \left( 1\right) +\left( 1\right) \left( 1\right) \left( 1\right) +\left( 1\right) \left( 1\right) \left( 1\right) \left( 1\right) +\left( 1\right) \left( 1$ 

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parts of the aggregate.

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code. If the place to

copy the object code is a network server, the Corresponding Source

may be on a different server (operated by you or a third party)

that supports equivalent copying facilities, provided you maintain  $% \left( 1\right) =\left( 1\right) \left( 1\right)$ 

clear directions next to the object code saying where to find the

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Corresponding Source, you remain obligated to ensure that it is

available for as long as needed to satisfy these requirements.

e) Convey the object code using peer-to-peer transmission, provided

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Source of the work are being offered to the general public at no  $\hfill \hfill \hfil$ 

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		use the GNU Lesser General Public License instead of this License. But first, please read
		Name: libquadmath
		Files: scipy.libs/libquadmath*.so Description: dynamically linked to files compiled with gcc
		Availability: https://gcc.gnu.org/git/? p=gcc.git;a=tree;f=libquadmath
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		**************************************



\documentclass[letterpaper,12pt]{article}

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		\usepackage[margin=lin]{geometry}
		\usepackage{verbatim}
		\usepackage{amsmath}
		\usepackage{supertabular}
		\usepackage{array}
		<pre>\def\T{{\hbox{\scriptsize{\rm T}}}}</pre>
		\def\epsilon{\varepsilon}
		\def\bigoh{\mathcal{0}}
		\def\phi{\varphi}
		<pre>\def\st{{\hbox{\scriptsize{\rm st}}}}</pre>
		<pre>\def\th{{\hbox{\scriptsize{\rm th}}}}</pre>
		<pre>\def\x{\mathbf{x}}</pre>
		ID: A software package for low-rank
		approximation
		of matrices via interpolative
		decompositions, Version 0.4}
		Per-Gunnar Martinsson, Vladimir Rokhlin
		Yoel Shkolnisky, and Mark Tygert}
		\begin{document}
		\maketitle
		\newpage
		{\parindent=0pt
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		{\tt id\_dist} and its subdirectories, or in the
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		}
		\newpage \tableofcontents
		\newpage
		\hrule

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Provider	Component	Licensing Information
		\medskip
		<pre>\centerline{\Large \bf IMPORTANT}</pre>
		\medskip
		\hrule
		\medskip
		<pre>\noindent At the minimum, please read Subsection~\ref{warning} and Section~\ref{naming} below, and beware that the {\it N.B.}'s in the source code comments highlight key information about the routines; {\it N.B.} stands for {\it nota bene} (Latin for `note well'').</pre>
		\medskip
		\hrule
		\bigskip
		\section{Introduction}
		This software distribution provides Fortran routines for computing low-rank approximations to matrices, in the forms of interpolative decompositions (IDs)
		and singular value decompositions (SVDs).  The routines use algorithms based on the ID.  The ID is also commonly known as the approximation obtained via skeletonization, the approximation obtained via subsampling, and the approximation obtained via subset selection.  The ID provides many advantages in many applications,
		and we suspect that it will become increasingly popular once tools for its computation become more widely available.  This software distribution includes some such tools, as well as tools for computing low-rank
		<pre>approximations in the form of SVDs. Section~\ref{defs} below defines IDs and SVDs,</pre>

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Provider	Component	Licensing Information
		and provides references to detailed discussions of the algorithms used in this software package.
		Please beware that normalized power iterations are better suited than the software in this distribution for computing principal component analyses in the typical case when the square of the signal-to-noise ratio is not orders of magnitude greater than both dimensions of the data matrix; see~\cite{halko-martinssontropp}.
		The algorithms used in this distribution have been optimized for accuracy, efficiency, and reliability; as a somewhat counterintuitive consequence, many must be randomized.  All randomized codes in this software package succeed with overwhelmingly high probability (see, for example, \cite{halko-martinsson-tropp}).  The truly paranoid are welcome to use the routines {\tt idd\_diffsnorm} and {\tt idz\_diffsnorm} to evaluate rapidly the quality of the approximations produced by the randomized algorithms  (as done, for example, in the files {\tt idd\_a\_test.f}, {\tt idz\_a\_test.f}, and {\tt idz\_r\_test.f} in the {\tt test} subdirectory  of the main directory {\tt id\_dist}).  In most circumstances, evaluating the quality of an approximation  via routines {\tt idd\_diffsnorm} or {\tt idz\_diffsnorm} is much faster  than forming the approximation to be evaluated.
		Still, we are unaware of any instance in which a properly-compiled routine failed to produce an accurate approximation.  To facilitate successful compilation, we encourage the user to read the instructions in the next section, and to read Section~\ref{naming}, too.

 $\verb|\sction{Compilation instructions}|$ 

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		Followed in numerical order, the subsections of
		this section provide step-by-step instructions for compiling
		the software
		under a Unix-compatible operating system.
		Beware that default command-line
		flags may not be
		sufficient for compiling the source
		codes!}
		\label{warning}
		The Fortran source codes in this distribution pass {\tt real*8}
		variables as integer variables, integers as {\ttreal*8}'s,
		{\tt real*8}'s as {\tt complex*16}'s, and so on.
		This is common practice in numerical codes, and is not an error;
		be sure to provide the relevant command-line
		flags to the compiler
		<pre>(for example, run {\tt fort77} and {\tt f2c} with the flag {\tt -!P}).</pre>
		When following the compilation instructions
		in Subsection~\ref{makefile_edit} below,
		be sure to set {\tt FFLAGS} appropriately.
		\subsection{Install LAPACK}
		The SVD routines in this distribution depend on LAPACK.
		Before compiling the present distribution,
		<pre>create the LAPACK and BLAS archive (library) {\tt .a} files;</pre>
		information about installing LAPACK is available
		<pre>at {\tt http://www.netlib.org/lapack/} (and several other web sites).</pre>
		Decompress and untar the file {\tt
		id\_dist.tar.gz}}
		At the command line, decompress and untar the file
		<pre>{\tt id\_dist.tar.gz} by issuing a command such</pre>
		<pre>as {\tt tar -xvvzf id\ dist.tar.gz}.</pre>
		This will create a directory named {\tt
		id\_dist}.
		\subsection{Edit the Makefile}
		(pappedetou(mare one mayerire)

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Provider	Component	Licensing Information
		\label{makefile_edit}
		The directory {\tt id\_dist} contains a file named {\tt Makefile}.  In {\tt Makefile}, set the following:
		<pre>\begin{itemize} \item {\tt FC} is the Fortran compiler. \item {\tt FFLAGS} is the set of command-line flags</pre>
		<pre>example)     for the Fortran compiler specified by {\tt</pre>
		<pre>FC};     please heed the warning in Subsection~\ref{warning} above! \item {\tt BLAS\_LIB} is the file-system path to the BLAS archive</pre>
		<pre>(library) {\tt .a} file. \item {\tt LAPACK\_LIB} is the file-system path to the LAPACK archive     (library) {\tt .a} file.</pre>
		<pre>\item {\tt ARCH} is the archiver utility (usually {\tt ar}). \item {\tt ARCHFLAGS} is the set of command-line flags</pre>
		for the archiver specified by $\{\t ARCH\}$ needed
		to create an archive (usually {\tt cr}). \item {\tt RANLIB} is to be set to {\tt ranlib} when {\tt ranlib} is available, and is to be set to {\tt echo}
		<pre>when {\tt ranlib} is not available. \end{itemize}</pre>
		\subsection{Make and test the libraries}
		At the command line in a shell that adheres to the Bourne shell conventions for redirection, issue the command ``{\tt make clean; make}'' to both create the archive (library)
		<pre>{\tt id\_lib.a} and test it. (In most modern Unix distributions, {\tt sh} is the Bourne shell, or else is fully compatible with the Bourne</pre>
		shell; the Korn shell {\tt ksh} and the Bourne-again shell {\tt bash} also use the Bourne shell conventions for
		<pre>also use the Bourne shell conventions for redirection.) {\tt make} places the file {\tt id\_lib.a} in the directory {\tt id\_dist}; the archive (library) file</pre>

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		<pre>{\tt id\_lib.a} contains machine code for all user-callable routines in this distribution.</pre>
		\section{Naming conventions} \label{naming}
		The names of routines and files in this distribution start with prefixes, followed by an underscore ('`\_'').  The prefixes are two to four characters in length, and have the following meanings:  % \begin{itemize} \ item The first two letters are always ``{\tt id}'',
		For example, {\tt iddr\_aid} is a {\tt real*8} routine which computes an approximation of specified rank. {\tt idz\_snorm} is a {\tt complex*16} routine. {\tt id\_randperm} is yet another routine in this distribution.
		\section{Example programs}
		For examples of how to use the user-callable

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		routines in this distribution, see the source codes in subdirectory {\tt test} of the main directory {\tt id\_dist}.
		\section{Directory structure}
		The main {\tt id\_dist} directory contains a Makefile, the auxiliary text files {\tt README.txt} and {\tt size.txt}, and the following subdirectories, described in the subsections below: % \begin{enumerate} \item {\tt bin} \item {\tt development} \item {\tt doc} \item {\tt test} \item {\tt tmp} \end{enumerate} %  If a ``{\tt make all}'' command has completed successfully, then the main {\tt id\_dist} directory will als contain an archive (library) file {\tt id\_lib.a} containing machine code for all of the user-callable routines.
		\subsection{Subdirectory {\tt bin}}  Once all of the libraries have been made via th Makefile in the main {\tt id\_dist} directory, the subdirectory {\tt bin} will contain object files (machine code), each compiled from the corresponding file of source code in the subdirectory {\tt src} of {\tt id\_dist}
		\subsection{Subdirectory {\tt development}}  Each Fortran file in the subdirectory {\tt development} (except for {\tt dfft.f} and {\tt prini.f}) specifies its dependencies at the top, then provides a main program for testing and debugging, and finally provides

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		for a library of user-callable subroutines. The Fortran file {\tt dfft.f} is a copy of P. N. Swarztrauber's FFTPACK library for computing fast Fourier transforms. The Fortran file {\tt prini.f} is a copy of V. Rokhlin's library of formatted printing routines. Both {\tt dfft.f} (version 4) and {\tt prini.f} are in the public domain. The shell script {\tt RUNME.sh} runs shell scripts {\tt make\_src.sh} and {\tt make\_test.sh}, which fill the subdirectories {\tt src} and {\tt test} of the main directory {\tt id\_dist} with source codes for user-callable routines and with the main program testing codes.
		\subsection{Subdirectory {\tt doc}}
		Subdirectory {\tt doc} contains this documentation, supplementing comments in the source codes.
		\subsection{Subdirectory {\tt src}}
		The files in the subdirectory {\tt src} provide source code for software libraries. Each file in the subdirectory {\tt src} (except for {\tt dfft.f} and {\tt prini.f}) is the bottom part of the corresponding file in the subdirectory {\tt development} of {\tt id\_dist}.  The file {\tt dfft.f} is just a copy of P. N. Swarztrauber's FFTPACK library for computing fast Fourier transforms.  The file {\tt prini.f} is a copy of V. Rokhlin's library of formatted printing routines.  Both {\tt dfft.f} (version 4) and {\tt prini.f} are in the public domain.
		\subsection{Subdirectory {\tt test}}  The files in subdirectory {\tt test} provide source code for testing and debugging. Each file in subdirectory {\tt test} is the top part of the corresponding file in subdirectory {\tt development} of {\tt

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		and provides a main program and a list of its
		dependencies.
		These codes provide examples of how to call th user-callable routines.
		\section{Catalog of the routines}
		The main routines for decomposing {\tt real*8} matrices are:
		\begin{enumerate}
		% \item IDs of arbitrary (generally dense)
		matrices:
		<pre>{\tt iddp\_id}, {\tt iddr\_id}, {\tt iddp\_aid {\tt iddr\_aid} }</pre>
		\item IDs of matrices that may be rapidly
		applied to arbitrary vectors
		<pre>(as may the matrices' transposes): {\tt iddp\ rid}, {\tt iddr\ rid}</pre>
		%
		<pre>\item SVDs of arbitrary (generally dense) matrices:</pre>
		{\tt iddp\ svd}, {\tt iddr\ svd}, {\tt
		iddp\_asvd},\\{\tt iddr\_asvd}
		\item SVDs of matrices that may be rapidly
		applied to arbitrary vectors
		(as may the matrices' transposes):
		{\tt iddp\_rsvd}, {\tt iddr\_rsvd}
		\end{enumerate}
		Similarly, the main routines for decomposing
		{\tt complex*16} matrices
		are:
		% \begin{enumerate}
		%
		<pre>\item IDs of arbitrary (generally dense) matrices:</pre>
		<pre>{\tt idzp\_id}, {\tt idzr\_id}, {\tt idzp\_aid} {\tt idzr\_aid}</pre>
		8
		\item IDs of matrices that may be rapidly
		<pre>applied to arbitrary vectors (as may the matrices' adjoints):</pre>
		{\tt idzp\ rid}, {\tt idzr\ rid}
		\$ ·· ·· · · · · · · · · · · · · · · ·
		<pre>\item SVDs of arbitrary (generally dense) matrices:</pre>
		(\++ ! d)d) (\++ ! d)d) (\++

{\tt idzp\\_svd}, {\tt idzr\\_svd}, {\tt

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

**Provider** Component **Licensing Information** idzp\ asvd},\\{\tt idzr\ asvd} \item SVDs of matrices that may be rapidly applied to arbitrary vectors (as may the matrices' adjoints): {\tt idzp\ rsvd}, {\tt idzr\ rsvd} \end{enumerate} This distribution also includes routines for constructing pivoted \$QR\$ decompositions (in  $\{\tt\ idd\_qrpiv.f\}\ and \{\tt$ idz\\_qrpiv.f}), for estimating the spectral norms of matrices that may be applied rapidly to arbitrary vectors as may their adjoints (in {\tt idd\ snorm.f} and {\tt idz\ snorm.f}), for converting IDs to SVDs (in  ${\time {\time id2svd.f}}$  and  ${\time id2svd.f}$ ), and for computing rapidly arbitrary subsets of the entries of the discrete Fourier transforms of vectors (in {\tt idd\ sfft.f} and {\tt idz\ sfft.f}). \subsection{List of the routines} The following is an alphabetical list of the routines in this distribution, together with brief descriptions of their functionality and the names of the files containing the routines' source code: \begin{center} \tablehead{\bf Routine & \bf Description & \bf Source file \\} \tabletail{\hline} \begin{supertabular}{>{\raggedright}p{1.2in} p{.53\textwidth} 1} \hline {\tt id\ frand} & generates pseudorandom numbers drawn uniformly from the interval  $\{[0,1]\}$ ; this routine is more efficient than routine {\tt id\ srand}, but cannot generate fewer than 55 pseudorandom numbers per call & {\tt id\ rand.f} \\\hline

Provider	Component	Licensing Information
		{\tt id\_frandi} & initializes the seed values
		for routine
		<pre>{\tt id\_frand} to specified values &amp; {\tt id\_rand.f} \\\hline</pre>
		{\tt id\_frando} & initializes the seed values for routine
		<pre>{\tt id\_frand} to their original, default values &amp; {\tt id\_rand.f} \\\hline</pre>
		8
		<pre>{\tt id\_randperm} &amp; generates a uniformly random permutation &amp;</pre>
		{\tt id\_rand.f} \\\hline
		{\tt id\_srand} & generates pseudorandom numbed drawn uniformly from
		the interval \$[0,1]\$; this routine is less efficient than routine
		{\tt id\_frand}, but can generate fewer than 5 pseudorandom numbers
		<pre>pseudorandom numbers per call &amp; {\tt id\_rand.f} \\\hline</pre>
		8
		<pre>{\tt id\_srandi} &amp; initializes the seed values for routine</pre>
		<pre>{\tt id\_srand} to specified values &amp; {\tt id\_rand.f} \\hline %</pre>
		{\tt id\_srando} & initializes the seed values for routine
		<pre>{\tt id\_srand} to their original, default values &amp; {\tt id\_rand.f}</pre>
		\\hline
		{\tt idd\_copycols} & collects together selecter columns of a matrix &
		{\tt idd\_id.f} \\hline
		<pre>{\tt idd\_diffsnorm} &amp; estimates the spectral norm of the difference</pre>
		between two matrices specified by routines for applying the matrices
		and their transposes to arbitrary vectors; thi routine uses the power
		<pre>method with a random starting vector &amp; {\tt idd\ snorm.f} \\\hline</pre>
		<del>-</del> 8
		{\tt idd\_enorm} & calculates the Euclidean no of a vector &
		{\tt idd\_snorm.f} \\\hline



(generally dense) matrix to a specified

rank of an arbitrary

precision; this routine is

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
i i o viaci	Component	Licensing intermation

```
randomized, and must be initialized with routine
{\tt idd\ frmi} &
{\tt iddp\ aid.f} \\\hline
{\tt idd\ frm} & transforms a vector into a
vector which is
sufficiently scrambled to be subsampled, via a
composition of Rokhlin's
random transform, random subselection, and a
fast Fourier transform &
{\tt idd\_frm.f} \\\hline
{\tt idd\ frmi} & initializes routine {\tt
idd\_frm} & {\tt idd\_frm.f}
\\\hline
{\tt idd\ getcols} & collects together selected
columns of a matrix
specified by a routine for applying the matrix
to arbitrary vectors &
{\tt idd\ id.f} \\\hline
{\tt idd\ house} & calculates the vector and
scalar needed to apply the
Householder transformation reflecting a given
vector into its first
entry & {\tt idd\ house.f} \\\hline
{\tt idd\ houseapp} & applies a Householder
matrix to a vector &
{\tt idd\ house.f} \\hline
{\tt idd\ id2svd} & converts an approximation to
a matrix in the form
of an ID into an approximation in the form of an
SVD &
{\tt idd\ id2svd.f} \\\hline
{\tt idd\ ldiv} & finds the greatest integer
less than or equal to a
specified integer, that is divisible by another
(larger) specified
integer & {\tt idd\_sfft.f} \\\hline
{\tt idd\ pairsamps} & calculates the indices of
the pairs of integers
that the individual integers in a specified set
belong to &
{\tt idd\ frm.f} \\\hline
{\tt idd\ permmult} & multiplies together a
bunch of permutations &
{\tt idd\ qrpiv.f} \\\hline
{\tt idd\ qinqr} & reconstructs the $Q$ matrix
```



Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		in a \$QR\$ decomposition
		from the output of routines {\tt iddp\_qrpiv} or
		{\tt iddr\ qrpiv} &
		{\tt idd\ qrpiv.f} \\\hline
		<del>-</del>

```
{\tt idd\ qrmatmat} & applies to multiple
vectors collected together as
a matrix the Q matrix (or its transpose) in
the $QR$ decomposition of
a matrix, as described by the output of routines
{\tt iddp\_qrpiv} or
{\time 
transpose) to a single vector
without having to provide a work array, use
routine {\tt idd\ qrmatvec}
instead & {\tt idd\ qrpiv.f} \\\hline
{\tt idd\ qrmatvec} & applies to a single vector
the $Q$ matrix (or its
transpose) in the $QR$ decomposition of a
matrix, as described by the
output of routines {\tt iddp\ qrpiv} or {\tt
iddr\ qrpiv}; to apply $Q$
(or its transpose) to several vectors
efficiently, use routine
{\tt idd\ qrmatmat} instead & {\tt idd\ qrpiv.f}
\\\hline
{\tt idd\ random\ } {\tt transf} & applies
rapidly a
random orthogonal matrix to a user-supplied
vector & {\tt id\_rtrans.f}
\\\hline
{ \dot c}  transf\_init} & \raggedright
initializes routines
{\tt idd\ random\ transf} and {\tt
idd\ random\ transf\ inverse} &
{\tt id\ rtrans.f} \\\hline
{\tt idd\_random\_} {\tt transf\_inverse} &
applies
rapidly the inverse of the operator applied by
routine
{\tt idd\ random\ transf} & {\tt id\ rtrans.f} \\
\hline
{\tt idd\ reconid} & reconstructs a matrix from
its ID &
{\tt idd\ id.f} \\\hline
{\tt idd\ reconint} & constructs $P$ in the
ID $A = B \setminus P$, where the
columns of $B$ are a subset of the columns
of $A$, and $P$ is the
```

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information

```
projection coefficient matrix, given {\tt list},
{\tt krank}, and
{\tt proj} output by routines {\tt iddr\ id},
{\tt iddp\_id},
{\tt iddr\ aid}, {\tt iddp\ aid}, {\tt
iddr\ rid}, or {\tt iddp\ rid} &
{\tt idd\ id.f} \\\hline
{\tt idd\ sfft} & rapidly computes a subset of
the entries of the
discrete Fourier transform of a vector, composed
with permutation
matrices both on input and on output & \{\t
idd\ sfft.f} \\hline
{\tt idd\ sffti} & initializes routine {\tt
idd\ sfft} &
{\tt idd\ sfft.f} \\\hline
{\tt idd\ sfrm} & transforms a vector into a
scrambled vector of
specified length, via a composition of Rokhlin's
random transform,
random subselection, and a fast Fourier
transform & {\tt idd\ frm.f}
\\\hline
용
{\tt idd\ sfrmi} & initializes routine {\tt
idd\ sfrm} &
{\tt idd\ frm.f} \\hline
{\t idd \ snorm} \ & \ estimates \ the \ spectral \ norm
of a matrix specified by
routines for applying the matrix and its
transpose to arbitrary
vectors; this routine uses the power method with
a random starting
vector & {\tt idd\ snorm.f} \\\hline
{\tt iddp\ aid} & computes the ID of an
arbitrary (generally dense)
matrix, to a specified precision; this routine
is randomized, and must
be initialized with routine {\tt idd\ frmi} &
{\tt iddp\ aid.f}
\\\hline
{\tt iddp\ asvd} & computes the SVD of an
arbitrary (generally dense)
matrix, to a specified precision; this routine
is randomized, and must
be initialized with routine {\tt idd\ frmi} &
{\tt iddp\ asvd.f}
\\\hline
```



Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
rioviuei	Component	{\tt iddp\_id} & computes the ID of an arbitrary (generally dense) matrix, to a specified precision; this routine is often less efficient than routine {\tt iddp\_aid} & {\tt idd\_id.f} \\ \hline % {\tt iddp\_qrpiv} & computes the pivoted \$QR\$ decomposition of an arbitrary (generally dense) matrix via Householder transformations, stopping at a specified precision of the decomposition & {\tt idd\_qrpiv.f} \\hline % {\tt idd\_qrpiv.f} \\hline % {\tt iddp\_rid} & computes the ID, to a
		<pre>specified precision, of a matrix specified by a routine for applying its transpose to arbitrary vectors; this routine is randomized &amp; {\tt iddp\_rid.f} \\\hline</pre>
		<pre>matrix specified by routines for applying the matrix and its transpose to arbitrary vectors; this routine is randomized &amp; {\tt iddp\_rsvd.f} \\\hline % {\tt iddp\_svd} &amp; computes the SVD of an</pre>
		<pre>arbitrary (generally dense) matrix, to a specified precision; this routine is often less efficient than routine {\tt iddp\_asvd} &amp; {\tt idd\_svd.f} \\\hline %</pre>
		<pre>{\tt iddr\_aid} &amp; computes the ID of an arbitrary (generally dense) matrix, to a specified rank; this routine is randomized, and must be initialized by routine {\tt iddr\_aidi} &amp; {\tt iddr\_aid.f} \\\hline %</pre>
		<pre>{\tt iddr\_aidi} &amp; initializes routine {\tt iddr\_aid} &amp; {\tt iddr\_aid.f} \\\hline</pre>
		<pre>matrix, to a specified rank; this routine is randomized, and must be initialized with routine {\tt idd\_aidi} &amp; {\tt iddr\_asvd.f} \\\hline</pre>



this routine is randomized & {\tt iddr\\_rid.f} \\

{\tt iddr\ rsvd} & computes the SVD, to a

{\tt iddr\ svd} & computes the SVD of an

matrix, to a specified rank; this routine is

routine {\tt iddr\\_asvd} & {\tt idd\\_svd.f} \\

{\tt idz\\_copycols} & collects together selected

{\tt idz\\_diffsnorm} & estimates the spectral

between two matrices specified by routines for

and their adjoints to arbitrary vectors; this

{\tt idz\\_enorm} & calculates the Euclidean norm

method with a random starting vector & {\tt

specified by routines for applying the matrix

arbitrary vectors; this routine is randomized &

specified rank, of a matrix  $% \left( \frac{1}{2}\right) =\frac{1}{2}\left( \frac{1}{2}\right) =\frac{1}{$ 

arbitrary (generally dense)

often less efficient than

columns of a matrix &
{\tt idz\\_id.f} \\hline

norm of the difference

applying the matrices

routine uses the power

idz\ snorm.f} \\hline

{\tt idz\ snorm.f} \\\hline

of a vector &

and its transpose to

{\tt iddr\ rsvd.f}

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		8
		<pre>{\tt iddr\_id} &amp; computes the ID of an arbitrar (generally dense)</pre>
		matrix, to a specified rank; this routine is often less efficient than
		<pre>routine {\tt iddr\_aid} &amp; {\tt idd\_id.f} \\ \hline</pre>
		<pre>% {\tt iddr\_qrpiv} &amp; computes the pivoted \$QR\$ decomposition of an</pre>
		arbitrary (generally dense) matrix via Householder transformations,
		stopping at a specified rank of the decomposition & {\tt idd\ qrpiv.f}
		\\hline
		<pre>% {\tt iddr\_rid} &amp; computes the ID, to a specified rank, of a matrix</pre>
		specified by a routine for applying its transpose to arbitrary vectors;

\hline

\\\hline

\hline



Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		{\tt idz\_estrank} & estimates the numerical

```
rank of an arbitrary
(generally dense) matrix to a specified
precision; this routine is
randomized, and must be initialized with routine
{\tt idz\ frmi} &
{\tt idzp\ aid.f} \\\hline
{\tt idz\ frm} & transforms a vector into a
vector which is
sufficiently scrambled to be subsampled, via a
composition of Rokhlin's
random transform, random subselection, and a
fast Fourier transform &
{\tt idz\ frm.f} \\hline
{\tt idz\ frmi} & initializes routine {\tt
idz\ frm} & {\tt idz\ frm.f}
\\\hline
{\tt idz\_getcols} & collects together selected
columns of a matrix
specified by a routine for applying the matrix
to arbitrary vectors &
{\tt idz\ id.f} \\\hline
{\tt idz\ house} & calculates the vector and
scalar needed to apply the
Householder transformation reflecting a given
vector into its first
entry & {\tt idz\ house.f} \\\hline
{\tt idz\_houseapp} & applies a Householder
matrix to a vector &
{\tt idz\ house.f} \\hline
{\tt idz\ id2svd} & converts an approximation to
a matrix in the form
of an ID into an approximation in the form of an
{\t idz\_id2svd.f} \ \
{\time {\time the greatest integer}} \ & finds the greatest integer
less than or equal to a
specified integer, that is divisible by another % \left( 1\right) =\left( 1\right) \left( 1\right) 
(larger) specified
integer & {\tt idz\_sfft.f} \\\hline
{\tt idz\ permmult} & multiplies together a
bunch of permutations &
{\tt idz\ qrpiv.f} \\\hline
{\time \{\time \time \t
in a $QR$ decomposition
from the output of routines {\tt idzp\ qrpiv} or
```



Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information

```
{\tt idzr\ qrpiv} &
{\tt idz\ qrpiv.f} \\\hline
{\tt idz\_qrmatmat} & applies to multiple
vectors collected together as
a matrix the $Q$ matrix (or its adjoint) in
the $QR$ decomposition of
a matrix, as described by the output of routines
{\tt idzp\_qrpiv} or
{\tt idzr\_qrpiv}; to apply $Q$ (or its adjoint)
to a single vector
without having to provide a work array, use
routine {\tt idz\_qrmatvec}
instead & {\tt idz\_qrpiv.f} \\\hline
{\tt idz\ qrmatvec} & applies to a single vector
the $Q$ matrix (or its
adjoint) in the $QR$ decomposition of a matrix,
as described by the
output of routines {\tt idzp\ qrpiv} or {\tt
idzr\_qrpiv}; to apply $Q$
(or its adjoint) to several vectors efficiently,
use routine
{\tt idz\ qrmatmat} instead & {\tt idz\ qrpiv.f}
\\\hline
{\tt idz\ random\ transf} & applies rapidly a
random unitary matrix to
a user-supplied vector & {\tt id\ rtrans.f} \\
\hline
{\tt idz\ random\ transf\ init} & \raggedright
initializes routines
{\time {\time idz\_random\_transf}} and {\time {\time idz\_random\_transf}}
idz\_random\_transf\_inverse} &
{\tt id\_rtrans.f} \\hline
{\tt idz\_random\_ transf\_inverse} & applies
rapidly the inverse of
the operator applied by routine { \tt
idz\_random\_transf} &
{\tt id\ rtrans.f} \\hline
{\tt idz\_reconid} & reconstructs a matrix from
its ID &
{\tt idz\ id.f} \\\hline
{\tt idz\ reconint} & constructs $P$ in the
ID A = B \setminus P, where the
columns of $B$ are a subset of the columns
of $A$, and $P$ is the
projection coefficient matrix, given {\tt list},
{\tt krank}, and
{\tt proj} output by routines {\tt idzr\ id},
{\tt idzp\ id},
```



Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		{\tt idzr\ aid}, {\tt idzp\ aid}, {\tt

```
idzr\ rid}, or {\tt idzp\ rid} &
{\tt idz\ id.f} \\\hline
{\tt idz\ sfft} & rapidly computes a subset of
the entries of the
discrete Fourier transform of a vector, composed
with permutation
matrices both on input and on output & {\tt
idz\ sfft.f} \\\hline
{\tt idz\ sffti} & initializes routine {\tt
idz\ sfft} &
{\tt idz\ sfft.f} \\\hline
{\tt idz\ sfrm} & transforms a vector into a
scrambled vector of
specified length, via a composition of Rokhlin's
random transform,
random subselection, and a fast Fourier
transform & {\tt idz\ frm.f}
\\\hline
0
{\tt idz\ sfrmi} & initializes routine {\tt
idz\ sfrm} &
{\tt idz\ frm.f} \\\hline
{\tt idz\ snorm} & estimates the spectral norm
of a matrix specified by
routines for applying the matrix and its adjoint
to arbitrary
vectors; this routine uses the power method with
a random starting
vector & {\tt idz\_snorm.f} \\\hline
{\t idzp\_aid} \ \& \ computes \ the \ ID \ of \ an
arbitrary (generally dense)
matrix, to a specified precision; this routine
is randomized, and must
be initialized with routine {\tt idz\ frmi} &
{\tt idzp\ aid.f}
\\\hline
{\t idzp\asvd} \ \& \ computes \ the \ SVD \ of \ an
arbitrary (generally dense)
matrix, to a specified precision; this routine
is randomized, and must
be initialized with routine {\tt idz\ frmi} &
{\tt idzp\ asvd.f}
\\\hline
{\tt idzp\ id} & computes the ID of an arbitrary
(generally dense)
matrix, to a specified precision; this routine
is often less efficient
```



Provider	Component	Licensing Information
		<pre>than routine {\tt idzp\_aid} &amp; {\tt idz\_id.f} \\ \hline  {\tt idzp\_qrpiv} &amp; computes the pivoted \$QR\$ decomposition of an arbitrary (generally dense) matrix via Householder transformations, stopping at a specified precision of the decomposition &amp; {\tt idz\_qrpiv.f} \\\hline </pre>
		<pre>% {\tt idzp\_rid} &amp; computes the ID, to a specified precision, of a matrix specified by a routine for applying its adjoint to arbitrary vectors; this routine is randomized &amp; {\tt idzp\_rid.f} \\\hline</pre>
		<pre>{</pre>
		<pre>% {\tt idzp\_svd} &amp; computes the SVD of an arbitrary (generally dense) matrix, to a specified precision; this routine is often less efficient than routine {\tt idzp\_asvd} &amp; {\tt idz\_svd.f} \\\hline</pre>
		<pre>{\tt idzr\_aid} &amp; computes the ID of an arbitrary (generally dense) matrix, to a specified rank; this routine is randomized, and must be initialized by routine {\tt idzr\_aidi} &amp; {\tt idzr\_aid.f} \\\hline</pre>
		<pre>% {\tt idzr\_aidi} &amp; initializes routine {\tt idzr\_aid} &amp; {\tt idzr\_aid.f} \\\hline %</pre>
		{\tt idzr\_asvd} & computes the SVD of an arbitrary (generally dense) matrix, to a specified rank; this routine is randomized, and must be initialized with routine {\tt idz\_aidi} & {\tt idzr\_asvd.f} \\\hline



 $\label{locality} $$ \{\tt idzr\_id\} \& computes the ID of an arbitrary (generally dense) $$$ matrix, to a specified rank; this routine is

Table 4-1 (Cont.) Open Source or Other Separately Licensed Software

Provider	Component	Licensing Information
		often less efficient than routine {\tt idzr\_aid} & {\tt idz\_id.f} \\ \hline
		%
		{\tt idzr\_qrpiv} & computes the pivoted \$QR\$ decomposition of an
		arbitrary (generally dense) matrix via Householder transformations,
		stopping at a specified rank of the
		<pre>decomposition &amp; {\tt idz\_qrpiv.f} \\\hline %</pre>
		{\tt idzr\_rid} & computes the ID, to a specified rank, of a matrix
		specified by a routine for applying its adjoint to arbitrary vectors;
		<pre>this routine is randomized &amp; {\tt idzr\_rid.f} \ \hline %</pre>
		{\tt idzr\_rsvd} & computes the SVD, to a specified rank, of a matrix
		specified by routines for applying the matrix and its adjoint to
		<pre>arbitrary vectors; this routine is randomized &amp; {\tt idzr\_rsvd.f} \\\hline</pre>
		<pre>% {\tt idzr\_svd} &amp; computes the SVD of an</pre>
		<pre>arbitrary (generally dense) matrix, to a specified rank; this routine is</pre>
		often less efficient than routine {\tt idzr\_asvd} & {\tt idz\_svd.f} \\
		<pre>% \end{supertabular} \end{center}</pre>
		\section{Documentation in the source codes}
		Each routine in the source codes includes
		documentation in the comments immediately following the
		<pre>declaration   of the subroutine's calling sequence.</pre>
		This documentation describes the purpose of the routine,
		the input and output variables, and the required work arrays (if any).
		This documentation also cites relevant references.
		<pre>Please pay attention to the {\it N.B.}'s; {\it N.B.} stands for {\it nota bene} (Latin for ``note well'')</pre>
		and highlights important information about the

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		routines.
		<pre>\section{Notation and decompositions} \label{defs}</pre>
		This section sets notational conventions employed in this documentation and the associated software, and defines both the singular value decomposition (SVD) and the interpolative decomposition (ID). For information concerning other mathematical objects used in the code (such as Householder transformations, pivoted \$QR\$ decompositions, and discrete and fast Fourier transforms DFTs and FFTs), see, for example, ~\cite{golub-van_loan}. For detailed descriptions and proofs of the
		<pre>mathematical facts discussed in the present section, see, for example, \cite{golub-van_loan} and the references in~\cite{halko-martinsson-tropp}.</pre>
		Throughout this document and the accompanying software distribution, \$\  \x \  \$ always denotes the Euclidean norm of the vector \$\x\$, and \$\  A \  \$ always denotes the spectral norm of the matrix \$A\$.  Subsection~\ref{Euclidean} below defines the Euclidean norm; Subsection~\ref{spectral} below defines the spectral norm.  We use \$A^*\$ to denote the adjoint of the matrix \$A\$.
		\subsection{Euclidean norm} \label{Euclidean}
		For any positive integer $n\$ , and vector $x\$ of length $n\$ , the Euclidean $1^2\$ norm $x\$ is % \begin{equation} \ \ \ x \ \ = \sqrt{ \sum_{k=1}^n  x_k ^2 }, \end{equation} \$\$ where $x_1\$ , $x_2\$ , \dots, $x_4\$ are the entries of $x_4\$ .

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```
\subsection{Spectral norm}
\label{spectral}
For any positive integers $m$ and $n$, and $m
\times n$ matrix $A$,
the spectral (1^2 operator) norm |A| A \|$ is
\begin{equation}
= \max \frac{1}{A_{m} \times n} \  \  \
1} \|}
           \{ \mid x_{n \in 1} \mid x_{n} \}
\end{equation}
where the $\max$ is taken over all $n \times 1$
column vectors $\x$
such that | x | ne 0.
\subsection{Singular value decomposition (SVD)}
For any positive real number $\epsilon$,
positive integers k, m, and n with k \le
m$ and k \le n,
and any $m \times n$ matrix $A$,
a rank-$k$ approximation to $A$ in the form of
(to precision $\epsilon$) consists of an $m
\times k$ matrix $U$
whose columns are orthonormal, an n \times k
matrix $V$
whose columns are orthonormal, and a diagonal \ensuremath{\,^{\mathrm{S}}} k
\times k$ matrix
$\Sigma$ with diagonal entries
\sigma {1,1}   \log \Omega {2,2}   \log \Omega 
Sigma \{n-1, n-1\}
                                       \ge
\sigma \{n,n\} \neq 0
such that
\begin{equation}
\ \ A_{m \to n} - U_{m \to k} \ \ Sigma_{k}
\times k}
                \epsilon.
\end{equation}
The columns of $U$ are known as left singular
vectors;
the columns of $V$ are known as right singular
vectors.
```



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		The diagonal entries of \$\Sigma\$ are known as singular values.
		When $\$k = m\$$ or $\$k = n\$$ , and $\$A = U \setminus \$igma \setminus V^*\$$ , then $\$U \setminus \$igma \setminus V^*\$$ is known as the SVD of $\$A\$$ ; the columns of $\$U\$$ are the left singular vectors of $\$A\$$ , the columns of $\$V\$$ are the right singular vectors of $\$A\$$ , and the diagonal entries of $\$\Sigma\$$ are the singular values of $\$A\$$ . For any positive integer $\$k\$$ with $\$k < m\$$ and $\$k < n\$$ , there exists a rank- $\$k\$$ approximation to $\$A\$$ in the form of an SVD, to precision $\$\Sigma_{k+1}\$$ , where $\$\Sigma_{k+1}\$$ is the $\$(k+1)^{\$}$ , where $\$\Sigma_{k+1}\$$ is the $\$(k+1)^{\$}$ , where $\$\Sigma_{k+1}\$$ is the $\$(k+1)^{\$}$ .
		\subsection{Interpolative decomposition (ID)}
		For any positive real number \$\epsilon\$, positive integers \$k\$, \$m\$, and \$n\$ with \$k \le m\$ and \$k \le n\$, and any \$m \times n\$ matrix \$A\$, a rank-\$k\$ approximation to \$A\$ in the form of an ID (to precision \$\epsilon\$) consists of a \$k \times n\$ matrix \$P\$, and an \$m \times k\$ matrix \$B\$ whose columns constitute a subset of the columns of \$A\$, such that
		<pre>\begin{enumerate} \item \$\  A_{m \in n} - B_{m \in k}  P_{k \in n} \ </pre>
		to a reasonably small positive real number, say 2. \end{enumerate}  % The product \$B  P\$ is known as an ID. The matrix \$P\$ is known as the projection or interpolation matrix of the ID. Property~1 above approximates each column of \$A\$ via a linear combination of the columns of \$B\$ (which are themselves columns of \$A\$), with the

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		coefficients in the linear combination given by the entries of \$P\$.
		The interpolative decomposition is `interpolative''
		<pre>due to Property~2 above. The ID is numerically stable due to Property~3 above. It follows from Property~2 that the least (\$k^\th\$ greatest) singular value of \$P\$ is at least 1. Combining Properties~2 and~3 yields that % \begin{equation} \  P_{k \times n} \  \le \sqrt{4k(n-k)+1}.</pre>
		<pre>\end{equation} When \$k = m\$ or \$k = n\$, and \$A = B  P\$, then \$B  P\$ is known as the ID of \$A\$. For any positive integer \$k\$ with \$k &lt; m\$ and \$i &lt; n\$,</pre>
		there exists a rank- $k$ approximation to $A$ in the form of an ID, to precision $\sqrt{k(n-k)+1} \$ ; $\sqrt{k+1}$ , where $\sqrt{k+1}$ is the $(k+1)^{s}$ greates singular value of $A$
		(in fact, there exists an ID in which every ent of the projection matrix \$P\$ has an absolute value less than or equal to 1).
		\section{Bug reports, feedback, and support}
		Please let us know about errors in the software or in the documentation via e-mail to {\tt tygert@aya.yale.edu}. We would also appreciate hearing about particular applications of the codes, especially in the form of journal articles e-mailed to {\tt tygert@aya.yale.edu}. Mathematical and technical support may also be available via e-mail. Enjoy!
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Name: OpenBLAS

Files: numpy/.dylibs/libopenblas\*.so

Description: bundled as a dynamically linked

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Availability: https://github.com/OpenMathLib/

OpenBLAS/

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Name: MT19937

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The rk\_random and rk\_seed functions algorithms and the original design of the Mersenne Twister RNG:

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Original algorithm for the implementation of rk\_interval function from Richard J. Wagner's implementation of the Mersenne Twister RNG, optimised by Magnus Jonsson.

Constants used in the  ${\rm rk\_double}$  implementation by Isaku Wada.

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Name: Julia

The ziggurat methods were derived from Julia.

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A C-program for MT19937, with initialization  $\ \ \,$ improved 2002/1/26.

Coded by Takuji Nishimura and Makoto Matsumoto.

Before using, initialize the state by using init genrand(seed)

or init by array(init key, key length).

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Modified by Jack Jansen, CWI, July 1995:

- Use binascii module to do the actual lineby-line conversion

between ascii and binary. This results in a 1000-fold speedup. The  $\ensuremath{\text{C}}$ 

version is still 5 times faster, though.

- Arguments more compliant with Python standard

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-----

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		strtod and dtoa
		The file: `Python/dtoa.c`, which supplies C functions dtoa and strtod for conversion of C doubles to and from strings, is derived from the file of the same name by David M. Gay, currently available from https://web.archive.org/web/20220517033456/http://www.netlib.org/fp/dtoa.c. The original file, as retrieved on March 16, 2009, contains the following copyright and licensing notice::
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		********
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\_\_\_\_\_

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./NOTICE

# Jackson JSON processor

Jackson is a high-performance, Free/Open Source JSON processing library. It was originally written by Tatu Saloranta (tatu.saloranta@iki.fi), and has

been in development since 2007. It is currently developed by a community of developers.

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#### Ramda

https://github.com/ramda/ramda

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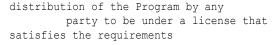
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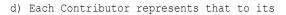


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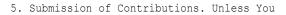


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