Parallel Computing Toolbox™ Release Notes

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Parallel Computing Toolbox™ Release Notes

R2022a

R2021b

R2021a

R2019b

R2018a

R2017b

R2015b

R2015a

R2022a

ValueStore and FileStore objects: Retrieve data and files on MATLAB clients during job execution

`ValueStore` and `FileStore` objects now allow you to store data and files from MATLAB® workers that can be retrieved by MATLAB clients during the execution of a job (even while the job is still running). These objects are not held in system memory, so they can be used to store large results. A `FileStore` object provides a universal location for workers to copy files. MATLAB clients can then access these files regardless of the specific cluster environment where the worker is running.

The `ValueStore` and `FileStore` objects are automatically created when you create a job on a cluster, a parallel pool of process workers on your local machine, or a parallel pool of workers on a cluster of machines. To access the `ValueStore` and `FileStore` objects on a worker, use the `getCurrentValueStore` and `getCurrentFileStore` functions, respectively.

Multifactor Authentication for the Generic Scheduler Interface: Connect to remote clients with RemoteClusterAccess using two or more authentication factors

`RemoteClusterAccess` objects now allow you to perform multifactor authentication, including two-factor authentication. To do so, specify `'Multifactor'` for the `AuthenticationMode` name-value argument. For details, see the `RemoteClusterAccess` reference page. The sample plugin scripts for third-party schedulers now accept `'Multifactor'` as the value for the `AuthenticationMode` property of `AdditionalProperties`, which sets that value on `RemoteClusterAccess`.

Cluster resizing: Customize your MATLAB Job Scheduler cluster to resize automatically

You can customize your MATLAB Job Scheduler (MJS) cluster to resize automatically. After you set up auto-resizing, also called auto-scaling, the cluster can automatically change the number of workers with the amount of work submitted. The cluster grows (scales up) when there is more work to do and shrinks (scales down) when there is less work to do. This allows you to use your compute resources more efficiently and can result in cost savings. To learn more, see “Set up MATLAB Job Scheduler Cluster for Auto-Resizing” (MATLAB Parallel Server).

Parallel Pools: Check status of pools

Starting in R2022a, you can query if any type of pool is currently running by using the `Busy` property of the pool. This property indicates whether the parallel pool is busy, specified as `true` or `false`. The pool is busy if there is outstanding work for the pool to complete.

Background Pool: Number of thread workers no longer limited to 8 workers

Before R2022a, the `NumWorkers` property was capped at a maximum of 8 workers when Parallel Computing Toolbox was installed, and 1 worker when not installed. This limit is no longer in place when the Parallel Computing Toolbox is installed. When Parallel Computing Toolbox is not installed, the background pool remains limited to 1 worker.

Thread-Based Parallel Pool: See futures in active pool

Starting in R2022a, you can query all queued and running futures on a parallel pool by using the `FevalQueue` property of the pool. To create futures, use `parfeval` and `parfevalOnAll`. For more information on futures, see `Future`.

cancelAll Method: Cancel currently queued and running futures in a parallel pool

`cancelAll` cancels all futures currently queued or running in a parallel pool. Queued or running futures are listed in the `FevalQueue` property.

For example, you can use `cancelAll` to stop all `Futures` in an `FevalQueue`.

```
pool = parpool;
cancelAll(pool.FevalQueue);
```

GPU Functionality: Use new and enhanced gpuArray functions

New GPU support in MATLAB:

- `besseli`, `besselk`
- `besselj`, `bessely` — Support for `scale` input argument
- `deconv`
- `eps`, `flintmax`, `intmax`, `intmin`, `realmax`, `realmin` — Support for `"like"` syntax to return scalars from prototype object
- `filter` — Support for all syntaxes and any vector sizes of the numerator and denominator coefficients of a rational transfer function in the input arguments
- `pagefun` — Support for `conv2`, `qr`, and `svd`
- `pageinv`
- `pagesvd`
- `svd`

For more information, see “Run MATLAB Functions on a GPU”.

New GPU support in Statistics and Machine Learning Toolbox™:

- `fitensemble`
- `fitrensemble`
- New support for probability functions: `gev*`, `gp*`, `nbin*`

For a list of all Statistics and Machine Learning Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Statistics and Machine Learning Toolbox).

The following functions have new and enhanced `gpuArray` support in Signal Processing Toolbox™:

- `findpeaks`
- `zerocrossrate`
- `pkurtosis`

- `pentropy`
- `levinson`
- `hilbert`
- `pow2db`
- `db2pow`

For a list of all Signal Processing Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Signal Processing Toolbox).

The following functions have new `gpuArray` support in Audio Toolbox™:

- `pitch`
- `audioDataAugmenter`
- `audioFeatureExtractor` - improved support

For a list of all Audio Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Audio Toolbox).

The following functions have new `gpuArray` and `dlArray` support in Wavelet Toolbox™:

- `imodwt`
- `modwt`
- `modwtmra`

For a list of all Wavelet Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Wavelet Toolbox).

Support for NVIDIA CUDA 11.2: Update to CUDA Toolkit 11.2

The parallel computing products now use CUDA® toolkit version `11.2`. To generate CUDA kernel objects from CU code or compile CUDA compatible source code, libraries, and executables using GPU Coder™, you must use toolkit version `11.2`. For more information, see “Run CUDA or PTX Code on GPU”.

Tall Arrays: Use new and enhanced tall array functionality

- `eps`, `flintmax`, `intmax`, `intmin`, `realmax`, `realmin` — Support for `"like"` syntax to return scalars from prototype object

For more information, see “Tall Arrays”.

Distributed Arrays: Use new and enhanced distributed array functionality

- `deconv`
- `eps`, `flintmax`, `intmax`, `intmin`, `realmax`, `realmin` — Support for `"like"` syntax to return scalars from prototype object
- `interp3`, `interpn`

- `movmad`, `movmax`, `movmean`, `movmedian`, `movmin`, `movprod`, `movstd`, `movsum`, `movvar`

For more information, see “Run MATLAB Functions with Distributed Arrays”.

Parallel Features in Other Products

Parallel features added in other products:

- Experiment Manager: Offload deep learning experiments as batch jobs in a cluster

  Starting in R2022a, **Experiment Manager** supports offloading experiments as batch jobs in a cluster. You can configure the cluster to run multiple trials at the same time or to run a single trial at a time on multiple parallel workers. While the experiment is running in the cluster, you can run other experiments, close the app and continue using MATLAB, or close your MATLAB session. For more information, see “Offload Experiments as Batch Jobs to Cluster” (Deep Learning Toolbox).
- Parallel Simulations: Perform parameter sweeps using Parameter Combinations

  In R2022a, you can use Parameter Combinations in the Multiple Simulations panel of the Simulink® Editor for workflows with multiple simulations, such as Monte-Carlo simulations and parameter sweeps. Parameter Combinations allows you to create sequential and exhaustive combinations of parameters, specify value ranges, and run simulations with these combinations. The Multiple Simulations panel was introduced in R2021b. For more information, see “Multiple Simulations Panel: Simulate for Different Values of Stiffness for a Vehicle Dynamics System” (Simulink).
- Machine Learning Apps: Train draft models in parallel or train in the background to keep the app responsive

  In **Classification Learner** and **Regression Learner**, you can train multiple draft models in parallel. You can use the **Use Parallel** or **Use Background** buttons while training models.

Solving Linear System: Improved performance when solving linear systems A*X = B with gpuArray for symmetric positive definite matrices A

Solving a linear system of the form `A*X = B` with `gpuArray` by executing `A\B` shows improved performance when `A` is a symmetric positive definite matrix.

For example, this code solves `A*X = B` for a 10,000-by-10,000 symmetric positive definite matrix `A` and a 10,000-by-1 column vector `B`. The code is about 2.4x faster than in the previous release.

```
function timingTest
rng default
R = rand(10000,"gpuArray");
A = R'*R;
B = ones(10000,1,"gpuArray");
X = A\B;
end
```

The approximate execution times are:

R2021b: 1.03 s

R2022a: 0.43 s

The code was timed on a Windows® 10, Intel® Xeon® CPU E5-1640 v3 @ 3.50 GHz with an NVIDIA® Titan V GPU test system using the `gputimeit` function:

```
gputimeit(@timingTest)
```

Functionality being removed or changed

distcomp folder removed, now named parallel

The `distcomp` folder has been removed.

In R2019b, the Parallel Computing Toolbox folder was renamed. Since then, the name of the toolbox folder has been `parallel`. If you need to reference the location of the toolbox, update your references to use `toolbox/parallel` instead of `toolbox/distcomp`.

R2021b

Parallel Language in MATLAB: Share parallel code with any MATLAB user

From R2021b, you can use more parallel language features in serial without Parallel Computing Toolbox. To scale up and speed up computations that use these features, use parallel pools and Parallel Computing Toolbox.

Additionally, you can now share parallel code with other MATLAB users who do not have Parallel Computing Toolbox.

The following features are now available in MATLAB:

- `parfeval` and related functionality such as `afterEach` and `afterAll`
- `parallel.pool.DataQueue`, `parallel.pool.PollableDataQueue`, and related functionality such as `afterEach`

For more information, see Background Processing and Write Portable Parallel Code.

GPU Functionality: Use new and enhanced gpuArray functions

- `makima`
- `movmad`
- `movmax`
- `movmedian`
- `movmin`
- `movprod`
- `pchip`
- `ppval`
- `filter` — Support for more than 10 elements for numerator coefficients of rational transfer function input argument.
- `pagefun` — Support for `conv`

For more information, see Run MATLAB Functions on a GPU.

GPU Functionality: Use new and enhanced gpuArray functions in Statistics and Machine Learning Toolbox

- `betafit` (Statistics and Machine Learning Toolbox)
- `fitcecoc` (Statistics and Machine Learning Toolbox)
- `fitcensemble` (Statistics and Machine Learning Toolbox)
- `fitctree` (Statistics and Machine Learning Toolbox)
- `fitdist` (Statistics and Machine Learning Toolbox)
- `fitrtree` (Statistics and Machine Learning Toolbox)
- `gevfit` (Statistics and Machine Learning Toolbox)
- `gpfit` (Statistics and Machine Learning Toolbox)

- `ksdensity` (Statistics and Machine Learning Toolbox)
- `mle` (Statistics and Machine Learning Toolbox)
- `mvksdensity` (Statistics and Machine Learning Toolbox)
- `nbinfit` (Statistics and Machine Learning Toolbox)

For a list of all Statistics and Machine Learning Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Statistics and Machine Learning Toolbox).

GPU Functionality: Use new and enhanced gpuArray functions for working with signals and audio

- The following functions have new and enhanced `gpuArray` support in Signal Processing Toolbox: For a list of all Signal Processing Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Signal Processing Toolbox).
  - `downsample` (Signal Processing Toolbox)
  - `filtfilt` (Signal Processing Toolbox)
  - `pspectrum` (Signal Processing Toolbox)
  - `resample` (Signal Processing Toolbox)
  - `shiftdata` (Signal Processing Toolbox)
  - `unshiftdata` (Signal Processing Toolbox)
  - `upfirdn` (Signal Processing Toolbox)
  - `upsample` (Signal Processing Toolbox)
  - `xspectrogram` (Signal Processing Toolbox)
- The following functions have new `gpuArray` support in Audio Toolbox:
  - `classifySound` (Audio Toolbox)
  - `crepePostprocess` (Audio Toolbox)
  - `crepePreprocess` (Audio Toolbox)
  - `detectSpeech` (Audio Toolbox)
  - `harmonicRatio` (Audio Toolbox)
  - `openl3Features` (Audio Toolbox)
  - `openl3Preprocess` (Audio Toolbox)
  - `pitchnn` (Audio Toolbox)
  - `vggishFeatures` (Audio Toolbox)
  - `vggishPreprocess` (Audio Toolbox)
  - `yamnetPreprocess` (Audio Toolbox)

  For a list of all Audio Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Audio Toolbox).

Memory Usage: Use whos to check memory used by gpuArray and distributed variables

You can now use the `whos` function to check the amount of memory used by `gpuArray` and `distributed` variables.

Previously, the `Bytes` variable of the output of `whos` showed the number of bytes of the pointer to the variable in the local memory of the host machine. Now, the `Bytes` variable displays the amount of GPU or distributed memory allocated to that variable. For `gpuArray` variables, `whos` displays the amount of GPU memory used by that variable. For `distributed` variables, `whos` displays the total memory used by that variable across all workers in the pool.

Distributed Arrays: Use new and enhanced distributed array functionality

- `interp2`
- `linsolve`
- `makima`
- `orth`
- `pagesvd`
- `pchip`
- `subspace`
- `svdsketch`
- `decomposition` – Support for new decompositions
  - For dense matrices, new support for banded decomposition and permuted triangular decomposition
  - For sparse matrices, new support for LDL decomposition and QR decomposition
- `pagefun` – Support for `conv`, `conv2`, and `svd`

For more information, see Run MATLAB Functions with Distributed Arrays.

Thread-Based Environment: Use new and enhanced functionality on threads for working with audio, video, and images

- The following MATLAB functions have new and enhanced thread support:
  - `imresize`
  - `audioread`
  - `audiowrite`
  - `imwrite`
  - `VideoReader`
  - `VideoWriter`
  - `imread` – Support for JPEG 2000 (J2C, J2K, JP2, JPF, JPX) format images on threads
- The following functions and objects have new thread support in Image Processing Toolbox™:

- `imcrop` (Image Processing Toolbox)
- `imcrop3` (Image Processing Toolbox)
- `imresize3` (Image Processing Toolbox)
- `imrotate` (Image Processing Toolbox)
- `imrotate3` (Image Processing Toolbox)
- `imtranslate` (Image Processing Toolbox)
- `impyramid` (Image Processing Toolbox)
- `imwarp` (Image Processing Toolbox)
- `affineOutputView` (Image Processing Toolbox)
- `findbounds` (Image Processing Toolbox)
- `fliptform` (Image Processing Toolbox)
- `makeresampler` (Image Processing Toolbox)
- `maketform` (Image Processing Toolbox)
- `tformarray` (Image Processing Toolbox)
- `tformfwd` (Image Processing Toolbox)
- `tforminv` (Image Processing Toolbox)
- `imregconfig` (Image Processing Toolbox)
- `imregcorr` (Image Processing Toolbox)
- `imregdemons` (Image Processing Toolbox)
- `imregmtb` (Image Processing Toolbox)
- `normxcorr2` (Image Processing Toolbox)
- `MattesMutualInformation` (Image Processing Toolbox)
- `MeanSquares` (Image Processing Toolbox)
- `RegularStepGradientDescent` (Image Processing Toolbox)
- `OnePlusOneEvolutionary` (Image Processing Toolbox)
- `cpcorr` (Image Processing Toolbox)
- `cpstruct2pairs` (Image Processing Toolbox)
- `fitgeotrans` (Image Processing Toolbox)
- `imref2d` (Image Processing Toolbox)
- `imref3d` (Image Processing Toolbox)
- `affine2d` (Image Processing Toolbox)
- `affine3d` (Image Processing Toolbox)
- `projective2d` (Image Processing Toolbox)
- `gray2ind` (Image Processing Toolbox)
- `ind2gray` (Image Processing Toolbox)
- `mat2gray` (Image Processing Toolbox)
- `label2rgb` (Image Processing Toolbox)
- `imsplit` (Image Processing Toolbox)
- `adaptthresh` (Image Processing Toolbox)

- `otsuthresh` (Image Processing Toolbox)
- `imquantize` (Image Processing Toolbox)
- `grayslice` (Image Processing Toolbox)
- `im2int16` (Image Processing Toolbox)
- `im2single` (Image Processing Toolbox)
- `im2uint16` (Image Processing Toolbox)
- `im2uint8` (Image Processing Toolbox)

For more information, see Run MATLAB Functions in Thread-Based Environment.

Functionality Being Removed or Changed

parfeval and parfevalOnAll can now run in serial with no pool

Behavior change

Starting in R2021b, you can now run `parfeval` and `parfevalOnAll` in serial with no pool. This behavior allows you to share parallel code that you write with users who do not have Parallel Computing Toolbox.

When you use the syntaxes `parfeval(fcn,n,X1,...,Xm)` or `parfevalOnAll(fcn,n,X1,...,Xm)`, MATLAB tries to use an open parallel pool if you have Parallel Computing Toolbox. If a parallel pool is not open, MATLAB will create one if automatic pool creation is enabled.

If parallel pool creation is disabled or if you do not have Parallel Computing Toolbox, the function is evaluated in serial. In previous releases, MATLAB threw an error instead.

mldivide and decomposition now produce the same results for distributed arrays

Behavior change

Starting in R2021b, `mldivide` and `decomposition` now produce the same results when you run the following code using distributed arrays `A` and `b`.

```
X = A \ b;
X = decomposition(A) \ b;
```

Previously, you sometimes saw different results when you used `decomposition` before `mldivide` for a non-square distributed matrix `A`.

Default behavior for decomposition has changed for distributed arrays

Behavior change

Starting in R2021b, the algorithm for `decomposition` with type set to `'auto'` (default) has changed for distributed array input. You see this behavior change when you use `decomposition` to decompose a distributed matrix that is Hermitian, banded, or permuted triangular.

When you use `decomposition(A)` or `decomposition(A,'auto')` with a distributed matrix `A`, the type of decomposition selected by MATLAB is limited to the supported decomposition types for distributed arrays.

- For a distributed dense matrix `A`, in the syntax `decomposition(A,type)` the decomposition types `'ldl'`, `'cod'`, and `'hessenberg'` are not supported.

- For a distributed sparse matrix `A`, in the syntax `decomposition(A,type)` the decomposition types `'chol'`, `'cod'`, and `'hessenberg'` are not supported.

R2021a

GPU Functionality: Use new and enhanced gpuArray functions

- `pagectranspose`
- `pagetranspose`
- `spline`
- `imresize` — Support for all non-sparse numeric or logical images, except categorical or indexed images. Support for `'nearest'` and `'bilinear'` interpolation methods. Support for `'box'`, `'triangle'`, `'cubic'`, `'lanczos2'`, `'lanczos3'`, and custom interpolation kernels. Support for `'AntiAliasing'` name-value argument.
- `issorted` — Support for `dim` and `direction` input arguments and `ComparisonMethod` name-value option.

For more information, see Run MATLAB Functions on a GPU.

GPU Functionality: Use new and enhanced gpuArray functions in Statistics and Machine Learning Toolbox

- `fitcknn` (Statistics and Machine Learning Toolbox)
- `gamfit` (Statistics and Machine Learning Toolbox)
- `pca` (Statistics and Machine Learning Toolbox)
- `randsample` (Statistics and Machine Learning Toolbox)

For a list of all Statistics and Machine Learning Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Statistics and Machine Learning Toolbox).

GPU Functionality: Use new and enhanced gpuArray functions for working with signals, audio, and wavelets

- The following functions have new and enhanced `gpuArray` support in Signal Processing Toolbox:

  - `binmask2sigroi` (Signal Processing Toolbox)
  - `bitrevorder` (Signal Processing Toolbox)
  - `buffer` (Signal Processing Toolbox)
  - `digitrevorder` (Signal Processing Toolbox)
  - `extendsigroi` (Signal Processing Toolbox)
  - `mergesigroi` (Signal Processing Toolbox)
  - `removesigroi` (Signal Processing Toolbox)
  - `shortensigroi` (Signal Processing Toolbox)
  - `sigroi2binmask` (Signal Processing Toolbox)
  - `sosfilt` (Signal Processing Toolbox)
  - `stftmag2sig` (Signal Processing Toolbox)

  For a list of all Signal Processing Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Signal Processing Toolbox).
- The following functions have new `gpuArray` support in Wavelet Toolbox:

  - `appcoef` (Wavelet Toolbox)
  - `appcoef2` (Wavelet Toolbox)
  - `detcoef` (Wavelet Toolbox)
  - `detcoef2` (Wavelet Toolbox)
  - `haart` (Wavelet Toolbox)
  - `haart2` (Wavelet Toolbox)
  - `idwt` (Wavelet Toolbox)
  - `idwt2` (Wavelet Toolbox)
  - `ihaart2` (Wavelet Toolbox)
  - `ihaart` (Wavelet Toolbox)
  - `waveletScattering` (Wavelet Toolbox)
  - `waverec` (Wavelet Toolbox)
  - `waverec2` (Wavelet Toolbox)

  For a list of all Wavelet Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Wavelet Toolbox).
- The following function has new `gpuArray` support in Audio Toolbox:
  - `audioFeatureExtractor` (Audio Toolbox)

  For a list of all Audio Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Audio Toolbox).

GPU Functionality: Use new and enhanced gpuArray functions in Image Processing Toolbox

- `imwarp` (Image Processing Toolbox)
- `imcrop` (Image Processing Toolbox)
- `multissim` (Image Processing Toolbox)
- `multissim3` (Image Processing Toolbox)
- `psnr` (Image Processing Toolbox)
- `wiener2` (Image Processing Toolbox)

For a list of all Image Processing Toolbox functions with GPU functionality, see Functions with gpuArray support (Image Processing Toolbox).

Support for NVIDIA CUDA 11.0: Update to CUDA Toolkit 11.0

The parallel computing products are now using CUDA toolkit version `11.0`. To generate CUDA kernel objects from CU code or compile CUDA compatible source code, libraries, and executables using GPU Coder, you must use toolkit version `11.0`. For more information, see GPU Support by Release.

Distributed Arrays: Use new and enhanced distributed array functionality

- `colon`
- `ichol`
- `interp1`
- `pagectranspose`
- `pagemtimes`
- `pagetranspose`

For more information, see Run MATLAB Functions with Distributed Arrays.

GPU Devices: Count and compare available GPU devices

Use new functionality to count and compare GPU devices in your local system

- `gpuDeviceCount` — Count all detected devices, all supported devices, or only devices available in your current session.
- `gpuDeviceTable` — Compare the properties of all local GPU devices detected in your system.

Thread-Based Parallel Pool: Use new and enhanced functionality on thread workers

- `imageDatastore`
- `imread`
- `parallel.pool.DataQueue`
- `parallel.pool.PollableDataQueue`
- Use thread workers in standalone applications created with MATLAB Compiler™ and web apps hosted on MATLAB Web App Server™.

For more information, see Run MATLAB Functions on Thread Workers.

parfor Examples: Use a parallel pool to speed up Monte-Carlo code

Use this new example to learn how to speed up your Monte-Carlo code using a `parfor`-loop. For more information, see Use `parfor` to Speed Up Monte-Carlo Code.

Upgrade Parallel Computing Products Together

As with every new release, if you upgrade Parallel Computing Toolbox, you must upgrade MATLAB Parallel Server™ at the same time so that they interact properly with each other.

Version History

If you are using MATLAB Job Scheduler, the backward compatibility feature allows you to connect to multiple versions of MATLAB Parallel Server in your cluster. For more information, see Run Multiple MATLAB Parallel Server Versions (MATLAB Parallel Server).

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Parallel Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` might not be compatible between different versions of MATLAB Parallel Server. You must specify a different `JobStorageLocation` for each parallel computing product, and each version on your cluster must have its own `JobStorageLocation`.

Functionality Being Removed or Changed

Support for cc3.0 and cc3.2 Kepler GPUs is removed
Errors

Starting in R2021a, support for Kepler GPU architectures with compute capability 3.0 and 3.2 is removed. Using a GPU with MATLAB requires a GPU device with compute capability 3.5 or greater. Using a GPU device with compute capability 6.0 or greater is recommended.

For more information about supported GPU devices, see GPU Support by Release.

Functions offloaded with batch now evaluate cell array input arguments {C1,...,Cn} as C1,...,Cn
Behavior change

Starting in R2021a, a function `fcn` offloaded with `batch` evaluates cell array input arguments `{C1,...,Cn}` as `fcn(C1,...,Cn)`. In previous releases `{C1,...,Cn}` threw an error and `{{C1,...,Cn}}` was evaluated as `fcn(C1,...,Cn)`.

Starting in R2021a, use the following code to offload `fcn({a,b},{c,d})` on the cluster `myCluster` with one output.

```
batch(myCluster,@fcn,1,{{a,b},{c,d}});
```

In previous releases, you used the following code instead.

```
batch(myCluster,@fcn,1,{{{a,b},{c,d}}});
```

R2020b

GPU Functionality: Use new and enhanced gpuArray functions

- `isgpuarray`
- `isoutlier`
- `pagemtimes`
- `rmmissing`
- `rmoutliers`
- Message functions `assert`, `error`, and `warning` (these functions gather `gpuArray` data and run on the CPU)
- `arrayfun` — Support for `cast` using `'like'` syntax
- `qr` — Support for one- and three-argument syntaxes

For more information, see Run MATLAB Functions on a GPU.

GPU Functionality: Use new and enhanced gpuArray functions in Statistics and Machine Learning Toolbox

- `fitlm` (Statistics and Machine Learning Toolbox)
- `fitglm` (Statistics and Machine Learning Toolbox)
- `glmfit` (Statistics and Machine Learning Toolbox)
- `glmval` (Statistics and Machine Learning Toolbox)
- `grp2idx` (Statistics and Machine Learning Toolbox)

For a list of all Statistics and Machine Learning Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Statistics and Machine Learning Toolbox).

GPU Functionality: Use new and enhanced gpuArray functions for working with signals, audio, and wavelets

- The following functions have new and enhanced `gpuArray` support in Signal Processing Toolbox:

  - `cpsd` (Signal Processing Toolbox)
  - `fsst` (Signal Processing Toolbox)
  - `goertzel` (Signal Processing Toolbox)
  - `istft` (Signal Processing Toolbox)
  - `mscohere` (Signal Processing Toolbox)
  - `periodogram` (Signal Processing Toolbox)
  - `pwelch` (Signal Processing Toolbox)
  - `spectrogram` (Signal Processing Toolbox) — Support for nonuniformly spaced frequencies

  For a list of all Signal Processing Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Signal Processing Toolbox).
- The following functions have new `gpuArray` support in Wavelet Toolbox:

  - `dwt` (Wavelet Toolbox)

  - `dwt2` (Wavelet Toolbox)
  - `dyadup` (Wavelet Toolbox)
  - `dyaddown` (Wavelet Toolbox)
  - `timeSpectrum`
  - `scaleSpectrum`
  - `wavedec` (Wavelet Toolbox)
  - `wavedec2` (Wavelet Toolbox)
  - `wcoherence` (Wavelet Toolbox)
  - `wextend` (Wavelet Toolbox)
  - `wkeep` (Wavelet Toolbox)

  For a list of all Wavelet Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Wavelet Toolbox).
- The following functions have new `gpuArray` support in Audio Toolbox:
  - `audioDelta` (Audio Toolbox)
  - `cepstralCoefficients` (Audio Toolbox)
  - `shiftPitch` (Audio Toolbox)
  - `spectralCentroid` (Audio Toolbox)
  - `spectralCrest` (Audio Toolbox)
  - `spectralDecrease` (Audio Toolbox)
  - `spectralEntropy` (Audio Toolbox)
  - `spectralFlatness` (Audio Toolbox)
  - `spectralFlux` (Audio Toolbox)
  - `spectralKurtosis` (Audio Toolbox)
  - `spectralRolloffPoint` (Audio Toolbox)
  - `spectralSkewness` (Audio Toolbox)
  - `spectralSlope` (Audio Toolbox)
  - `spectralSpread` (Audio Toolbox)
  - `stretchAudio` (Audio Toolbox)

  For a list of all Audio Toolbox functions with GPU functionality, see Functions with `gpuArray` support (Audio Toolbox).

GPU Communications: Fast data transfer between GPUs in a parallel pool

Data transfer between GPUs in a parallel pool now uses fast peer-to-peer communication, including NVLink, if available. Fast data transfer takes place when you send `gpuArray` data using the following functions:

- `labSend`
- `labReceive`

- labBroadcast
- gop

Support for NVIDIA CUDA 10.2: Update to CUDA Toolkit 10.2

The parallel computing products are now using CUDA toolkit version `10.2`. To compile CUDA code for `CUDAKernel` or CUDA MEX-files, you must use toolkit version `10.2`. For more information, see GPU Support by Release.

Distributed Arrays: Use new and enhanced distributed array functionality

- filter
- mpower
- pagefun
- rmmissing

For more information, see Run MATLAB Functions with Distributed Arrays.

Tall Arrays: Use new and enhanced tall array functionality in Signal Processing Toolbox

- `pwelch` (Signal Processing Toolbox)

For a list of all Signal Processing Toolbox functions with support for tall arrays, see Functions with `tall` support (Signal Processing Toolbox).

Array Assignment: Assign gpuArray or distributed data directly into existing MATLAB arrays

You can now assign values stored in a `gpuArray`, `distributed` array, or `codistributed` array into a MATLAB array directly, without first having to gather the data. In assignment statements such as `A(1:k) = C`, where `A` has a built-in data type such as `double`, MATLAB attempts to convert `C` to the same data type as `A`. That conversion behavior has changed.

For example, the following code now runs.

```
x = rand(3,3);
y = rand(1,'gpuArray');
x(2,2) = y;
```

Version History

Some assignment statements that used to throw an error now execute. If your code relied on the errors that MATLAB threw for those conversions, such as within a `try/catch` block, then your code might no longer catch those errors.

Distributed Tables: Assign data directly into existing distributed tables

You can now assign values directly into a distributed table. In assignment statements such as `distTable.Score(1:k) = C`, where `distTable.Score` has a built-in data type such as `double`, MATLAB attempts to convert `C` to the same data type as `distTable.Score`. That conversion behavior has changed.

For example, the following code now runs.

```
table = array2table(rand(2),'VariableNames',{'ID','Score'});
distTable = distributed(table);
distTable.Score(1:2) = [1 2];
```

Version History

Some assignment statements that used to throw an error now execute. If your code relied on the errors that MATLAB threw when assigning values into a distributed table, such as within a `try/catch` block, then your code might no longer catch those errors.

Thread-Based Parallel Pool: Use a gpuArray on thread workers

You can now use a `gpuArray` on thread workers. Any functionality with both GPU and `ThreadPool` support now supports GPUs in a `ThreadPool`. For more information, see Check Support for Thread-Based Environment.

parfeval Examples: Explore the state of futures and cancel them

Use this new example to learn how to query the state of `parfeval` futures and cancel them. For more information, see Query and Cancel `parfeval` Futures.

HTCondor integration: Plugin script for HTCondor now available as an Add-On

Integrate the third party scheduler HTCondor and MATLAB via the generic scheduler interface using an easy-to-configure plugin script. To download the plugin script, use the Add-On Explorer. Alternatively, you can download the plugin from the File Exchange. For more information, see Configure Using the Generic Scheduler Interface (MATLAB Parallel Server).

Parallel Workflows: Compare performance of different parallel environments

Use new examples to determine the best parallel programming environment to use in your workflows:

- Compare Performance of Multithreading and `ProcessPool`
- Compare Performance of `parfor`, `parfeval`, and `spmd`

Query Underlying Data: Query the underlying data type of classes

You can now use the following functions to query the underlying data type of data stored in `gpuArray` objects, `distributed` arrays, `dlarray` objects, and more:

- `underlyingType`
- `isUnderlyingType`
- `mustBeUnderlyingType`

The `class` function is useful to determine the class of a variable. However, some classes in MATLAB can contain underlying data that has a different type compared to what `class` returns. Example classes include `gpuArray`, `dlarray`, and `distributed` arrays. The `underlyingType`, `isUnderlyingType`, and `mustBeUnderlyingType` functions now provide a simple way to query the underlying data types of those classes.

For most classes, `class(X)` and `underlyingType(X)` return the same answer. However, for classes that can contain underlying data of a different type, `class(X)` returns the name of the class (such as `gpuArray`), and `underlyingType(X)` returns the underlying MATLAB data type that determines how the array `X` behaves (such as `double`).

Query Parallel Functionality: Query if support for Parallel Computing Toolbox functionality is available

You can now query if support for GPU and parallel pool functionality is available in your MATLAB installation using the following functions:

- `canUseGPU`
- `canUseParallelPool`

Use these functions to check supported functionality and avoid executing code that relies on specific hardware constraints.

Improved Scalability: Use MATLAB Job Scheduler clusters with up to 4000 workers

MATLAB Parallel Server with the MATLAB Job Scheduler now supports clusters up to `4000` workers. Support for large parallel pools remains at `1024` workers.

When you scale above `1000` workers, you must increase the heap memory available to the job manager. For more information, see Customize Startup Parameters (MATLAB Parallel Server).

Reference Architectures: Schedule jobs to run in AWS Batch

Use the MATLAB Parallel Server with AWS Batch reference architecture to build your own MATLAB Parallel Server solution for batch processing jobs using AWS Batch. AWS Batch dynamically provisions and manages Amazon EC2® instances based on the volume and resource requirements of the submitted jobs. AWS Batch supports both On-Demand and Spot Amazon EC2 instances.

To connect to the cluster from your MATLAB client, install the Parallel Computing Toolbox plugin for MATLAB Parallel Server with AWS Batch.

Docker Containers: Build a container image with a customized MATLAB installation

Use the reference Dockerfile to build a Docker container image that runs a custom MATLAB installation. You can choose the toolboxes you require in your custom installation. Containers are a scalable and reproducible method to deploy MATLAB in cloud and server environments. To access the Dockerfile and create a custom MATLAB container image, see Create a MATLAB Container Image.

labSend, labReceive, labBroadcast and gop Functions: Improved performance of data transfer between GPUs in a parallel pool

The `labSend`, `labReceive`, `labBroadcast` and `gop` functions show improved performance when transferring data in a parallel pool between MATLAB workers with GPUs. Data transfer between GPUs in a parallel pool now uses fast peer-to-peer communication, including NVLink, if available. For example, using the `labSend` and `labReceive` functions to transfer 72 MB data between two GPUs is approximate 5.1x faster than in the previous release.

```
% Set up parallel pool
parpool('local',2);

% Clear all GPUs
spmd
    gpuDevice([]);
end

% Set sender/receiver worker index
senderIndex = 1;
receiverIndex = 2;

% Create data
spmd
    devices = gpuDevice();
    if labindex == senderIndex
        gpuData = ones(3000,3000,'gpuArray');
    end
    wait(devices);
end

% Measure time to transfer data 20 times
tic;
for j=1:20
    spmd
        if labindex == senderIndex
            labSend(gpuData,receiverIndex);
        elseif labindex == receiverIndex
            newGpuData = labReceive(senderIndex);
        end
        wait(devices);
    end
end
toc

% Delete parallel pool
delete(gcp('nocreate'))
```

The approximate execution times are:

R2020a: 9.50 seconds

R2020b: 1.85 seconds

The code was timed on a Windows 10, Intel Xeon E5-2623 v4 @ 2.60 GHz test system with four NVIDIA Titan V 12GB GPUs by running the above script.

Upgrade Parallel Computing Products Together

As with every new release, if you upgrade Parallel Computing Toolbox, you must upgrade MATLAB Parallel Server at the same time so that they interact properly with each other.

Version History

If you are using MATLAB Job Scheduler, the backward compatibility feature allows you to connect to multiple versions of MATLAB Parallel Server in your cluster. For more information, see Run Multiple MATLAB Parallel Server Versions (MATLAB Parallel Server).

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Parallel Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` might not be compatible between different versions of MATLAB Parallel Server. You must specify a different `JobStorageLocation` for each parallel computing product, and each version on your cluster must have its own `JobStorageLocation`.

Functionality Being Removed or Changed

GPU acceleration is not available on macOS

Errors

Starting in R2020b, GPU acceleration, including `gpuArray` and CUDA functionality, is not supported on macOS platforms. Using `gpuArray` or CUDA functionality on macOS platforms results in an error.

For more information on platforms supported by MATLAB, see Platform Road Map for MATLAB and Simulink. For more information on GPU support for macOS, see Can I use MATLAB with an NVIDIA GPU on macOS 10.14 Mojave?

Forward compatibility for GPU devices is disabled by default

Behavior change

Starting in R2020b, forward compatibility for GPU devices is disabled by default. In previous releases, forward compatibility for GPU devices is enabled and cannot be disabled.

When forward compatibility is disabled, you cannot perform computations using a GPU device with an architecture that was released after the version of MATLAB you are using was built.

To reproduce the behaviour of earlier MATLAB versions, enable forward compatibility using the `parallel.gpu.enableCUDAForwardCompatibility` function or by setting the environment variable `MW_CUDA_FORWARD_COMPATIBILITY` to `1`.

For more information, see Forward Compatibility for GPU Devices.

classUnderlying and isaUnderlying are not recommended

Still runs

`classUnderlying` and `isaUnderlying` are not recommended. Use `underlyingType` and `isUnderlyingType` instead.

R2020a

Parallel profiling: Learn tips and techniques to profile parallel code with new documentation

Use this new example to learn how to profile your parallel code and find out what functions parallel pool workers are spending most of the time on. For more information, see Profile Parallel Code.

GPU Functionality: Use new and enhanced gpuArray functions

- `mldivide`: Support for batch operations on rectangular matrices.
- `tril`: Support for batch operations.
- `triu`: Support for batch operations.
- `qmr`
- `tfqmr`

For more information, see Run MATLAB Functions on a GPU.

GPU Functionality: Use new and enhanced gpuArray functions in Statistics and Machine Learning Toolbox

Over 140 functions in Statistics and Machine Learning Toolbox have support for gpuArrays. Functions with new `gpuArray` support include:

- `corr`
- `random`

For a full list of functions with new and enhanced GPU functionality, see *Release Notes for Statistics and Machine Learning Toolbox* (Statistics and Machine Learning Toolbox).

GPU Functionality: New gpuArray support for spectral functions

Several spectral functions in Audio Toolbox, Signal Processing Toolbox, and Wavelet Toolbox now support gpuArrays. The following functions now have `gpuArray` support:

- `mfcc` (Audio Toolbox)
- `melSpectrogram` (Audio Toolbox)
- `czt` (Signal Processing Toolbox)
- `spectrogram` (Signal Processing Toolbox)
- `stft` (Signal Processing Toolbox)
- `wvd` (Signal Processing Toolbox), `wvd` (Wavelet Toolbox)
- `cwt` (Wavelet Toolbox)
- `cwtfilterbank` and `wt` object function (Wavelet Toolbox)

Job Arrays: Submit job arrays to third-party schedulers with the generic scheduler interface

Now MATLAB leverages job arrays by default when you submit jobs to Slurm, LSF®, PBS Pro®, and Grid Engine using the generic scheduler interface. For more information on integrating a third-party scheduler with MATLAB and the generic scheduler interface, see Integrate MATLAB with Third-Party Schedulers (MATLAB Parallel Server) and Configure Using the Generic Scheduler Interface (MATLAB Parallel Server).

Distributed Arrays: Use new and enhanced distributed array functionality

- `matches`
- `ilu`
- `del2`
- `inpolygon`
- `polyfit`
- `polyval`
- `renamevars`
- `write`: support for new name-value pairs `'VariableEncoding'` and `'Version'` for writing Parquet files.
- `subsasgn`: support for indexed deletion.

For more information, see Run MATLAB Functions with Distributed Arrays.

New Thread-Based Parallel Pool: Optimized for reduced memory usage, faster scheduling, and less data transfer, for a subset of MATLAB functions

You can now run parallel language features on a thread-based parallel pool. Thread-based environments are optimized for reduced memory usage, faster scheduling, and less data transfer. These environments are an alternative to the existing family of process-based environments.

Thread workers support a subset of the MATLAB functions available for process workers. If you are interested in a function that is not supported, let the MathWorks Technical Support team know.

The features that thread workers support are `parpool`, `parfor`, `parfeval`, `tall`, and `parallel.pool.Constant`. Features that are not supported include `spmd`, `distributed`, and `parallel.pool.DataQueue`.

In general, many core features of MATLAB are supported, including:

- Language fundamentals
- Mathematics
- Core data types (double, single, logical, integer types, char, cell arrays, string, table, timetable, categorical, datetime, and duration)
- Control flow and logic (for example, if, for loops, and while loops)
- Scripts, functions and classes
- Custom classes

In general, features that modify or access things outside of the thread worker are not supported, including:

- Data import and export
- Graphics
- External languages

For more information, see Choose Between Thread-Based and Process-Based Environments.

MATLAB Online: Use Parallel Computing Toolbox with Cloud Center clusters in MATLAB Online

You can now use Parallel Computing Toolbox in MATLAB Online™ with Cloud Center clusters. Access MATLAB Online from here: https://matlab.mathworks.com. To learn more about the specific capabilities and the differences from MATLAB Desktop, see Use Parallel Computing Toolbox with Cloud Center clusters in MATLAB Online.

Upgrade Parallel Computing Products Together

As with every new release, if you upgrade Parallel Computing Toolbox you must upgrade MATLAB Parallel Server at the same time so that they interact properly with each other.

Version History

If you are using MATLAB Job Scheduler, the backward compatibility feature allows you to connect to multiple versions of MATLAB Parallel Server in your cluster. For more information, see Run Multiple MATLAB Parallel Server Versions (MATLAB Parallel Server).

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Parallel Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Parallel Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

Functionality Being Removed or Changed

GPU acceleration is not available on macOS 10.14 Mojave and later versions
Errors

GPU acceleration, including `gpuArray` and CUDA functionality, is not supported on macOS 10.14 Mojave and later versions. Using `gpuArray` or CUDA functionality on macOS 10.13 High Sierra and earlier versions results in a warning.

For more information, see Can I use MATLAB with an NVIDIA GPU on macOS 10.14 Mojave?.

Support for Kepler and Maxwell GPUs will be removed
Warns

In a future release, support for Kepler and Maxwell GPU architectures will be removed. At that time, using a GPU with MATLAB will require a GPU device with compute capability 6.0 or greater. Pascal, Volta, and Turing architectures are supported GPU architectures with compute capability 6.0 or greater.

In R2020a, Kepler and Maxwell GPUs are still supported. MATLAB generates a warning the first time you use a Kepler or Maxwell GPU.

For more information about supported GPU devices, see GPU Support by Release.

pmode will be removed
Warns

In a future release, the `pmode` function will be removed. To execute commands interactively on multiple workers, use `spmd` instead.

pload and psave will be removed
Warns

In a future release, the `psave` and `pload` functions will be removed. To save and load data on the workers, in the form of Composite arrays or distributed arrays, use `dsave` and `dload` instead.

R2019b

GPU Functionality: Use new and enhanced gpuArray functions

- `min`, `max`: Support for the `'linear'` option.
- `diag`, `trace`: Support for sparse gpuArrays.
- `times, .*`: Support for sparse gpuArrays.

For more information, see Run MATLAB Functions on a GPU.

Support for NVIDIA CUDA 10.1: Update to CUDA Toolkit 10.1

The parallel computing products are now using CUDA Toolkit version `10.1`. To compile CUDA code for `CUDAKernel` or CUDA MEX-files, you must use toolkit version `10.1`. For more information, see GPU Support by Release.

gpuArray: Load gpuArray data when no GPU is available

You can now load MAT files containing gpuArray data as in-memory arrays when a GPU is not available. A `gpuArray` object loaded without a GPU is limited and you cannot use it for computations. To use a gpuArray loaded without a GPU, retrieve the contents with `gather`.

mexcuda: Compile mexcuda functions without installing the CUDA toolkit

You can now use `mexcuda` to compile CUDA code without installing the CUDA toolkit. If the CUDA toolkit is not detected or is not a supported version, MATLAB compiles the CUDA code using the NVIDIA `nvcc` compiler installed with MATLAB. To check which compiler `mexcuda` is using, use the `-v` flag for verbose output in the `mexcuda` command.

Distributed Arrays: Use new and enhanced distributed array functionality

- `decomposition`
- `min`, `max`: Support for the `'linear'` option.
- `mink`, `maxk`, `topkrows`
- `issorted`, `issortedrows`
- `distributed`: Support for creating a distributed array from a Composite array.
- Support for accessing whole rows or columns in 2-D block-cyclic distributed arrays.

For more information, see Run MATLAB Functions with Distributed Arrays.

Distributed Arrays Examples: Explore multigrid preconditioned iterative solvers with new documentation

Use this new example to learn how to use a multigrid preconditioned iterative solver with distributed arrays. For more information, see Solve Differential Equation Using Multigrid Preconditioner on Distributed Discretization.

Parallel Deep Learning Workflows: Explore deep learning with custom parallel training loops

Use this new example to learn how to set up custom training loops to train deep learning networks in parallel. For more information, see Train Network in Parallel with Custom Training Loop.

Batch Jobs Examples: Explore batch workflows with new documentation

Use these new examples to learn about batch jobs and options:

- Run Script as Batch Job
- Run Batch Job and Access Files from Workers

parfeval Examples: Explore parfeval workflows with new documentation

Use these new examples to learn more about `parfeval` workflows:

- Plot During Parameter Sweep with `parfeval`
- Perform Webcam Image Acquisition in Parallel with Postprocessing
- Perform Image Acquisition and Parallel Image Processing

Image Acquisition Examples: Perform parallel acquisition and processing of images

Use these new examples to learn how to implement these parallel workflows:

- Perform Webcam Image Acquisition in Parallel with Postprocessing
- Perform Image Acquisition and Parallel Image Processing

Improved Scalability: Use MATLAB Job Scheduler clusters with up to 2000 workers

MATLAB Parallel Server with the MATLAB Job Scheduler now supports clusters up to `2000` workers. Support for large parallel pools remains at `1024` workers.

Third-Party Schedulers: Check the scheduler ID of a MATLAB task

If you submit a task to a third-party scheduler, then you can check its ID on the scheduler by looking at the `SchedulerID` property of the task object. For more information, see CJS Tasks. To get the scheduler IDs of all tasks in a job, use `getTaskSchedulerIDs`.

Common Job Schedulers: Improved performance of vectorized task creation

Local and third-party schedulers benefit from improved task creation rates and submission times when you use `createTask` for vectorized task creation or `parfor` without a parallel pool.

For example, the following functions show about a 75x speed-up for task creation and a 6x speed-up for job submission.

```
function taskCreationTimingTest
    c = parcluster('local');
    j = createJob(c);
    numTasks = 10000;
    allTaskArgs = cell(1,numTasks);
    for ii = 1:numTasks
        ithTaskArgs = {ii}; % Arguments to the ith task
        allTaskArgs{ii} = ithTaskArgs;
    end
    tic;
    createTask(j,@rand,1,allTaskArgs);
    toc
end

function jobSubmissionTimingTest
    c = parcluster('local');
    j = createJob(c);
    numTasks = 10000;
    allTaskArgs = cell(1,numTasks);
    for ii = 1:numTasks
        ithTaskArgs = {ii}; % Arguments to the ith task
        allTaskArgs{ii} = ithTaskArgs;
    end
    createTask(j,@rand,1,allTaskArgs);
    tic;
    submit(j);
    toc
end
```

The approximate times are:

- R2019a: 296 s for task creation and 150 s for job submission.
- R2019b: 3.9 s for task creation and 24 s for job submission.

The code was timed on a Windows 10, Intel Xeon W-2133 CPU @ 3.60 GHz test system using the `timeit` function:

```
timeit(@taskCreationTimingTest)
timeit(@jobSubmissionTimingTest)
```

Personalized Clusters: Set Cloud Center clusters for personal use

Now Cloud Center clusters can have two levels of authorization: for personal use or sharable. For more information, see Create Cloud Cluster.

Upgrade Parallel Computing Products Together

As with every new release, if you upgrade Parallel Computing Toolbox you must upgrade MATLAB Parallel Server at the same time so that they interact properly with each other.

Version History

If you are using MATLAB Job Scheduler, the backward compatibility feature allows you to connect to multiple versions of MATLAB Parallel Server in your cluster. For more information, see Run Multiple MATLAB Parallel Server Versions (MATLAB Parallel Server).

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Parallel Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Parallel Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

Functionality Being Removed or Changed

Toolbox folder renamed from distcomp to parallel
Behavior change

In R2019b, the Parallel Computing Toolbox folder has been renamed. The new name for the toolbox folder is `parallel`. If you need to reference the location of the toolbox, update your references to use `toolbox/parallel` instead of `toolbox/distcomp`.

pmode will be removed
Still runs

In a future release, the `pmode` function will be removed. To execute commands interactively on multiple workers, use `spmd` instead.

pload and psave will be removed
Still runs

In a future release, the `psave` and `pload` functions will be removed. To save and load data on the workers, in the form of Composite arrays or distributed arrays, use `dsave` and `dload` instead.

R2019a

parfor-Loops: Use parfor without a parallel pool

`parfor` can now run without a parallel pool of workers. If you choose this approach, `parfor` uses the available cluster resources as needed. You can also control options, such as the worker load, with `parforOptions`.

Parallel Deep Learning Workflows: Explore deep learning with multiple-GPUs

Use these new examples to learn how to use multiple GPUs to train a single or several deep learning networks in parallel.

- Train Network Using Automatic Multi-GPU Support
- Run Multiple Deep Learning Experiments

Benchmarks: Use new examples to evaluate the performance of your cluster

Use the computational tests in these benchmarks to measure the performance of your compute cluster.

- Benchmark Cluster Workers
- Benchmark Your Cluster with the HPC Challenge

parpool Resiliency: Parallel pools are now resilient to dropped network connections

Parallel pools are now robust to network failures, and can recover from connectivity issues. For example, if your network connection drops, MATLAB attempts to reconnect to the workers in the pool. There is no loss of data if the disconnection happens during data transfer.

Automatic Cluster Resizing: Resize Cloud Center clusters on Amazon based on usage

You can now create cloud clusters that resize automatically based on usage. These clusters grow or shrink to allocate the optimal number of workers for your submitted tasks. For more information, see the MathWorks Cloud Center documentation.

Custom Datastore: Read from Hadoop based databases using the custom datastore framework

Author a custom database datastore and access data from a database of your choice using these extensions:

- `matlab.io.datastore.HadoopLocationBased` – Use this mixin to specify the location of your data in Hadoop®.
- `matlab.io.datastore.HadoopInput` – Use this helper class when a Hadoop java class is available for a database library.

Perform big data analysis on your custom datastore with tall arrays or `mapreduce`. These custom datastores can leverage the location of the data to make computations more efficient.

For more information on the custom datastore framework, see Develop Custom Datastore (MATLAB).

GPU Functionality: Use new and enhanced gpuArray functions

- `sinpi`
- `cospi`
- `normalize`
- `validateattributes`

For more information, see Run MATLAB Functions on a GPU.

Support for NVIDIA CUDA 10.0: Update to CUDA Toolkit 10.0

The parallel computing products are now using CUDA Toolkit version `10.0`. To compile CUDA code for `CUDAKernel` or CUDA MEX-files, you must use toolkit version `10.0`. For more information, see GPU Support by Release.

Distributed Arrays: Use new and enhanced distributed array functionality

- `sinpi`
- `cospi`
- `normalize`
- `validateattributes`
- `write`: Support for writing to Parquet files
- `eig`: Support for non-symmetric matrices
- `sprandsym`
- Distributed iterative solvers, such as `pcg` or `gmres`, now allow arbitrary matrices as preconditioners

For more information, see Run MATLAB Functions with Distributed Arrays.

Renamed Product: MATLAB Distributed Computing Server renamed to MATLAB Parallel Server

MATLAB Distributed Computing Server™ now has the name MATLAB Parallel Server. To learn more about MATLAB Parallel Server, see MATLAB Parallel Server.

Support for MPICH: Update to MPICH Version 3 on Linux for third-party schedulers

The parallel computing products are now shipping MPICH version `3.2.1` on Linux for third-party schedulers. Communicating jobs for third-party schedulers now use the Hydra process manager.

Version History

If you use your own MPI builds, you might need to create new builds compatible with this latest version. For instructions, see Use Different MPI Builds on UNIX Systems (MATLAB Parallel Server).

Upgrade Parallel Computing Products Together

As with every new release, if you upgrade Parallel Computing Toolbox you must upgrade MATLAB Parallel Server at the same time so that they interact properly with each other.

Version History

If you are using MATLAB Job Scheduler, the backward compatibility feature allows you to connect to multiple versions of MATLAB Parallel Server in your cluster. For more information, see Run Multiple MATLAB Parallel Server Versions (MATLAB Parallel Server).

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Parallel Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Parallel Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

Functionality Being Removed or Changed

Default random number generator changed for parallel contexts
Behavior change

Starting in R2019a, the default random number generator for parallel computations is changed to `Threefry`. This change applies to calculations on parallel workers, GPU arrays, distributed arrays, and tall arrays. This generator offers performance enhancements for parallel calculations over the previous default. In releases up to and including R2018b, the default random number generator for parallel computations is `CombRecursive`.

With a different default generator, MATLAB generates different random number sequences by default in the context of parallel computations. However, the statistics of these calculations remain unaffected. Therefore, you might want to update any code that relies on the specific random numbers being generated, but most calculations on the random numbers are unaffected.

To set the generator to the settings used by default in R2018b and earlier on parallel workers, GPU arrays, and tall arrays, use the following commands.

Calculations on parallel workers and distributed arrays:

```
spmd
   stream = RandStream.create("CombRecursive", "NumStreams", 2^32,...
       "StreamIndices", 2*labindex);
   RandStream.setGlobalStream(stream);
end
```

Calculations on GPU arrays:

```
gpurng(0,"CombRecursive")
```

Calculations on tall arrays:

```
tallrng(0,"CombRecursive")
```

Toolbox folder renamed from distcomp to parallel
Behavior change in future release

In R2019b, the Parallel Computing Toolbox toolbox folder will be renamed. The new name for the toolbox folder is `parallel`. If you need to reference the location of the toolbox, update your references to use `toolbox/parallel` instead of `toolbox/distcomp`.

R2018b

GPU Support: View details of GPU support on over 600 function pages, and browse GPU support for functions by toolbox

Consult additional GPU usage information on function pages of GPU-enabled functions in MATLAB and other toolboxes. You can find this information in the Extended Capabilities section at the end of the function page. Also, browse GPU function lists filtered by product. For more information, see Run MATLAB Functions on a GPU.

GPU Functionality: Use new and enhanced gpuArray functions, such as spline interpolation and vecnorm

- `interp1`: support for `'spline'` interpolation method
- `vecnorm`
- `norm` for sparse gpuArrays: support for all vector norms; and `1`, `Inf`, and frobenius matrix norms
- Reduction functions (`min`, `max`, `sum`,...): support for reducing multiple dimensions simultaneously
- `nthroot`: support for logical inputs
- `sign`: support for logical inputs

For more information, see Run MATLAB Functions on a GPU.

Support for NVIDIA CUDA 9.1: Update to CUDA Toolkit 9.1

The parallel computing products are now using CUDA Toolkit version `9.1`. To compile CUDA code for CUDAKernel or CUDA MEX-files, you must use toolkit version `9.1`. For more information, see GPU Support by Release.

GPU Optimizations: Enhanced support and optimizations for GPU

- `gpuDevice` and `gpuDeviceCount` now run faster if you do not have a GPU, because they do not load the GPU libraries. You can use these functions to check if a setup supports GPUs or not.
- GPU memory management is now better optimized. Benefit from improved performance in memory intensive GPU applications, such as deep learning.

GPU Examples: Explore GPU workflows on single and multiple GPUs

New and updated GPU documentation now includes:

- Use MATLAB Functions with a GPU
- Identify and Select a GPU Device
- Sharpen an Image Using the GPU
- Run MATLAB Functions on Multiple GPUs
- Use Multiple GPUs in a Parallel Pool
- gpuArray
- Establish Arrays on a GPU
- GPU Support by Release

Distributed Arrays: Use new and enhanced distributed array functionality, including support for vecnorm and writing to Amazon S3 and Azure

- `vecnorm`
- `write`: support for writing to `XLS`, `CSV`, and `TXT` formats
- `write`: extended support for writing `SEQ` and `MAT` formats to all supported file systems
- `write`: support for writing to S3 and WASBS filesystems
- Reduction functions (`min`, `max`, `sum`,...): support for reducing multiple dimensions simultaneously
- `nthroot`: support for logical inputs
- `sign`: support for logical inputs
- Distributed timetable support
- `mldivide`: more robust sparse distributed system solve

For more information, see Run MATLAB Functions with Distributed Arrays.

Distributed Support: View details of distributed array support on over 400 function pages, and browse distributed support for functions by toolbox

Consult additional distributed array usage information on function pages of distributed-enabled functions in MATLAB and other toolboxes. You can find this information in the Extended Capabilities section at the end of the function page. Also, browse distributed array function lists filtered by product. For more information, see Run MATLAB Functions with Distributed Arrays.

Parallel Extended Capabilities: View details of automatic parallel support on function pages, and browse support for functions by toolbox

Many functions in MATLAB, Simulink, and toolboxes help you take advantage of parallel computing resources without requiring any extra coding. You can enable this support by simply setting a flag or preference.

Now you can consult automatic parallel usage information on function pages and browse supported function lists filtered by product.

Similarly, you can view lists of functions with extended capabilities for GPU arrays and Distributed arrays enabled by Parallel Computing Toolbox.

For details, see

- Run MATLAB Functions with Automatic Parallel Support
- Run MATLAB Functions on a GPU
- Run MATLAB Functions with Distributed Arrays

Write Cloud Data: Write distributed arrays and tall arrays to Amazon S3 and Windows Azure storage

If you have access to cloud storage in Amazon S3™ or Windows Azure Blob Storage, you can upload your distributed and tall data using the `write` function. When you write data from a cluster in the same cloud service, the data transfer is more efficient. To learn more about your options for accessing cloud storage, see Work with Remote Data (MATLAB).

Big Data in the Cloud: Explore MATLAB capabilities for big data

A new example shows how to access a publicly available dataset in the cloud and work with it using datastores, tall arrays and Parallel Computing Toolbox. This example shows you step-by-step how to use MATLAB to analyse huge datasets. See Process Big Data in the Cloud.

Improved Scalability: Use up to 1024 workers per parallel pool

MATLAB Distributed Computing Server can now support clusters with up to `1024` workers. Use large parallel pools of workers for big scaling problems.

Streamlined Cloud Cluster Setup: Create new Cloud Center clusters directly from the MATLAB desktop

You can now create a MATLAB Distributed Computing Server enabled cluster on Amazon EC2 directly from MATLAB. On the **Home** tab, in the **Environment** area, select **Parallel > Create and Manage Clusters**, and choose **Create Cloud Cluster** to set up a new cloud cluster. For more information, see Create Cloud Cluster.

Cluster Workflows: Learn how to scale up from desktop to cluster

Use this new example to learn how to prototype interactively your parallel code on your local machine and scale up to a cluster. For more information, see Scale up from Desktop to Cluster.

Streamlined Installation Documentation: Simplified workflows for integrating MATLAB Distributed Computing Server in your cluster

Follow simplified workflows to integrate your third-party scheduler or MATLAB Job Scheduler with MATLAB Distributed Computing Server in your cluster. For details, see Getting Started with MATLAB Distributed Computing Server (MATLAB Distributed Computing Server).

Generic Scheduler Documentation: Set up Schedulers Using Improved Instructions

Follow improved instructions to integrate a third-party scheduler using the generic scheduler interface. For more information, see Configure Using the Generic Scheduler Interface (MATLAB Distributed Computing Server).

Parallel Deep Learning Workflows: Explore deep learning with multiple GPUs locally or in the cloud

Use examples to explore options for scaling up deep learning training. You can use multiple GPUs locally or in the cloud without changing your code. Use parallel computing to train multiple networks locally or on cloud clusters, and use datastores to access cloud data. New examples include:

- Train Network in the Cloud Using Built-in Parallel Support
- Use parfor to Train Multiple Deep Learning Networks
- Use `parfeval` to Train Multiple Deep Learning Networks
- Upload Deep Learning Data to the Cloud
- Send Deep Learning Batch Job To Cluster

To learn about options, see Scale Up Deep Learning in Parallel and in the Cloud (Deep Learning Toolbox).

Upgrade Parallel Computing Products Together

As with every new release, if you upgrade Parallel Computing Toolbox you must upgrade MATLAB Distributed Computing Server at the same time so that they interact properly with each other.

Version History

If you are using MATLAB Job Scheduler, the backward compatibility feature allows you to connect to multiple versions of MATLAB Distributed Computing Server in your cluster. For more information, see Run Multiple MATLAB Distributed Computing Server Versions (MATLAB Distributed Computing Server).

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Distributed Computing Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Distributed Computing Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

Functionality Being Removed or Changed

Philox4x32-10 and Threefry4x64-20 random number generators renamed
Still runs

The Random123 random number generators Philox and Threefry are renamed to match the names used in MATLAB. `Philox4x32-10` is renamed to `Philox4x32_10` or `Philox`. `Threefry4x64-20` is renamed to `Threefry4x64_20` or `Threefry`.

- Replace all instances of `Philox4x32-10` with `Philox4x32_10` or `Philox`
- Replace all instances of `Threefry4x64-20` with `Threefry4x64_20` or `Threefry`

The names `Philox4x32-10` and `Threefry4x64-20` continue to work but are not recommended. There are no plans to remove support for these names at this time.

Default random number generator will change for parallel contexts

Behavior change in future release

In a future release, the default random number generator for parallel computations will change to `Threefry`. This change will apply to calculations on parallel workers, GPU arrays, distributed arrays, and tall arrays. This generator will offer performance enhancements for parallel calculations over the current default. In releases up to R2018b, the default random number generator for parallel computations is `CombRecursive`.

With a different default generator, MATLAB will generate different random numbers sequences by default in the context of parallel computations. However, statistics of these calculations will remain unaffected. Therefore, you might want to update any code that relies on the specific random numbers being generated, but most calculations on the random numbers should be unaffected.

To set the generator to the settings used by default in R2018b and earlier on parallel workers, GPU arrays, and tall arrays, use the following commands.

Calculations on parallel workers and distributed arrays:

```
spmd
   stream = RandStream.create("CombRecursive", "NumStreams", 2^32,...
       "StreamIndices", 2*labindex);
   RandStream.setGlobalStream(stream);
end
```

Calculations on GPU arrays:

```
gpurng(0,"CombRecursive")
```

Calculations on tall arrays:

```
tallrng(0,"CombRecursive")
```

Support for MATLAB Parallel Cloud is removed

Starting in R2018b, support for MATLAB Parallel Cloud clusters is removed. For easy-to-use scaling, you can use MathWorks Cloud Center to run MATLAB on preconfigured, customizable cloud clusters powered by Amazon EC2. To find out more about MathWorks Cloud Center, see Parallel Computing on the Cloud with MATLAB and MathWorks Cloud Center.

R2018a

Parfeval callbacks: New afterAll and afterEach methods for parallel futures

You can use the new methods `afterAll` and `afterEach` to specify functions to automatically execute when parallel futures complete. You create parallel futures using the `parfeval` function. A useful application for `afterEach` and `afterAll` is to update user interfaces such as plots and apps during parallel computations using `parfeval`. For an example, see Update a User Interface Asynchronously Using `afterEach` and `afterAll`.

Slurm support: Slurm is a fully supported scheduler

Slurm is now a fully supported scheduler. You can create Slurm profiles directly in the Profile Manager without needing templates and scripts from File Exchange. For more information, see Configure for Slurm, PBS Pro, Platform LSF, TORQUE.

Support for NVIDIA Volta: Update to CUDA 9, support for Volta class GPUs

The parallel computing products are now using CUDA Toolkit version 9.0. To compile CUDA code for `CUDAKernel` or CUDA MEX-files, you must use toolkit version 9.0.

This update improves support for Volta class GPUs.

Improved file mirroring: Performance of file mirroring for generic scheduler integration

File mirroring for the generic scheduler integration has been improved through the use of zip archives.

Parfor performance improvements: More efficient broadcast variables in parfor for non-local clusters

If you use broadcast variables in `parfor` loops with non-local clusters, now performance is improved. Broadcast variables in `parfor` loops are sent only once to the cluster, instead of once per worker.

GPU Array Support: Use enhanced gpuArray functions

You can now use the following enhanced `gpuArray` functions:

- `rescale`
- new syntaxes of `sort` and `sortrow`

For more information, see Run Built-In Functions on a GPU.

Distributed Array Support: Use enhanced distributed array functions

You can now use the following enhanced distributed array functions:

- `rescale`
- new syntaxes of `sort` and `sortrow`
- `bicgstabl`

For more information, see Using MATLAB Functions on Distributed Arrays.

Parameter Sweep Example: Use a DataQueue to monitor results during computations on a parallel pool

The new example *Plot during Parameter Sweep with parfor* shows how to perform a parameter sweep in parallel and plot progress during parallel computations. For details, see Plot during Parameter Sweep with `parfor`.

Discontinued Support for GPU Devices of Compute Capability less than 3.0

In R2018a, support for GPU devices of compute capability less than 3.0 is removed. A minimum compute capability of 3.0 is required for GPU computing in MATLAB. For more information on using GPUs, see GPU Computing in MATLAB.

Version History

In R2018a, any use of `gpuDevice` to select a GPU with compute capability less than 3.0 generates an error. Support is removed for devices with compute capability less than 3.0.

Backwards Compatibility for MATLAB Job Scheduler: Upgrade MATLAB Job Scheduler clusters, and continue to use previous releases of Parallel Computing Toolbox

You can upgrade your MATLAB Job Scheduler clusters to the latest release and still connect to it using previous releases (back to R2016a) of Parallel Computing Toolbox on your MATLAB desktop client. For the supported older releases, you must maintain an installation of the same release of MATLAB Distributed Computing Server for each release of MATLAB you want to use. The latest MATLAB Job Scheduler routes your jobs accordingly. You can configure MATLAB Job Scheduler with the location of these installations in the `mdce_def` file. For more information, see Install Products and Choose Cluster Configuration.

Upgrade Parallel Computing Products Together

As with every new release, if you upgrade Parallel Computing Toolbox you must upgrade MATLAB Distributed Computing Server at the same time so that they interact properly with each other. Note that you do not need to do this if you are taking advantage of MATLAB Job Scheduler's backwards compatibility.

The R2018a version of Parallel Computing Toolbox software is accompanied by a corresponding new version of MATLAB Distributed Computing Server software.

Version History

As with every new release, if you are using both parallel computing products, you must upgrade Parallel Computing Toolbox and MATLAB Distributed Computing Server together. These products must be the same version to interact properly with each other. This requirement applies only if you are not taking advantage of MATLAB Job Scheduler backwards compatibility.

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Distributed Computing Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Distributed Computing Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

Functionality Being Removed or Changed

Functionality	**Result**	**Use Instead**	**Compatibility Considerations**
Support for GPU devices of compute capability less than 3.0 is removed.	Errors	Use GPUs with a minimum compute capability of 3.0.	Support is removed for GPU devices of compute capability 2.x. Use GPUs with a minimum compute capability 3.0. Use the function `gpuDevice` to query the compute capabilities of your GPUs. For more information, see GPU Computing in MATLAB.
`parallel.gpu.rng` is renamed to `gpurng`	Still runs	`gpurng`	Replace all instances of `parallel.gpu.rng` with `gpurng`

R2017b

Improved Parallel Language Performance: Execute parallel language constructs with reduced overhead

All parallel language constructs, including `parfor`, run with reduced overhead, particularly constructs with short duration. The scheduling of `parfor`-loop intervals has been changed to utilize the cluster hardware more efficiently.

Tall Array Support: Use tall arrays with Windows client access to Linux Spark clusters

You can use tall arrays on Spark™ enabled Hadoop clusters supporting all architectures for the client, while supporting Linux and Mac architectures for the cluster. This includes cross-platform support.

Improved Parallel Pool Robustness: Run pools without Message Passing Interface (MPI) by default, making pools resilient to workers crashing

You can now run parallel pools without MPI by default, improving the resilience of your parallel pool to workers crashing.

Improved MATLAB Integration with Third-Party Schedulers: Use the Generic Profile Wizard for easier installation and setup of MATLAB Distributed Computing Server

You can now use the new workflow to automatically create generic profiles using the support packages for third-party schedulers. For more details, see Distribute a Generic Cluster Profile and Integration Scripts (MATLAB Distributed Computing Server).

Cloud Storage: Work with data in Microsoft Azure Blob Storage

You can now use Microsoft® Azure® Blob Storage to access data in the cloud using `datastore`. For more information on this topic, see Distribute a Generic Cluster Profile and Integration Scripts (MATLAB Distributed Computing Server).

Copy Client Environment to Workers on Any Cluster: Specify which environment variables on your client machine your workers should automatically inherit

You can now mirror any of your client environment variables to the workers on a cluster. For example, you can include any environment variables required by third-party software. Or you can include cloud service provider credentials in your local environment to give worker processes access to your data stored in the cloud.

You can now set `EnvironmentVariables` in parpool, batch, createJob and in the Cluster Profile Manager. `EnvironmentVariables` is also a common property of the parallel.Job class.

Client Path Sharing: Add user-added-entries on the client’s path to the workers’ paths

You can now automatically add user-added-entries on the client’s path to the workers’ paths for batch and independent jobs. This functionality can be enabled or disabled by specifying the `AutoAddClientPath` option to the parpool, batch and createJob commands. `AutoAddClientPath` is also a common property of the parallel.Job class.

GPU Array Support: Use enhanced gpuArray functions

You can now use the following enhanced `gpuArray` functions:

- `bounds` for computing `max` and `min` simultaneously
- Sparse iterative solvers `cgs` and `lsqr`
- `spdiags`

For more information on this topic, see Run Built-In Functions on a GPU.

Distributed Array Support: Use enhanced distributed array functions

You can now use the following enhanced `distributed` array functions:

- Sparse iterative solvers `minres`, `symmlq` and `bicgstab`
- `bounds` for computing `max` and `min` simultaneously
- `eigs`
- `spdiags`

For more information, see Using MATLAB Functions on Distributed Arrays.

Enhanced Support for Microsoft Windows HPC Pack

The parallel computing products now support Microsoft Windows HPC Pack 2016. For details, see Configure for HPC Pack (MATLAB Distributed Computing Server).

Discontinued Support for GPU Devices of Compute Capability less than 3.0

In a future release, support for GPU devices of compute capability less than 3.0 will be removed. At that time, a minimum compute capability of 3.0 will be required.

Version History

In R2017b, any use of `gpuDevice` to select a GPU with compute capability less than 3.0, generates a warning. The device is still supported in this release, but in a future release support will be completely removed for devices with compute capability less than 3.0.

Backwards Compatibility for MATLAB Job Scheduler: Upgrade MATLAB Job Scheduler clusters, and continue to use previous releases of Parallel Computing Toolbox

You can upgrade your MATLAB Job Scheduler clusters to R2017b and still connect to it using the R2017a, R2016b, and R2016a releases of Parallel Computing Toolbox on your MATLAB desktop client. For releases prior to R2016b, you must maintain an installation of the same release of MATLAB Distributed Computing Server for each release of MATLAB you want to use. The latest MATLAB Job Scheduler routes your jobs accordingly. You can configure MATLAB Job Scheduler with the location of these installations in the `mdce_def` file. For more information, see Install Products and Choose Cluster Configuration (MATLAB Distributed Computing Server).

Upgrade Parallel Computing Products Together

The R2017b version of Parallel Computing Toolbox software is accompanied by a corresponding new version of MATLAB Distributed Computing Server software.

Version History

As with every new release, if you are using both parallel computing products, you must upgrade Parallel Computing Toolbox and MATLAB Distributed Computing Server together. These products must be the same version to interact properly with each other. This requirement applies only if you are not taking advantage of MATLAB Job Scheduler backwards compatibility.

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Distributed Computing Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Distributed Computing Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

Functionality Being Removed or Changed

Functionality	Result	Use Instead	Compatibility Considerations
Support for running MATLAB MapReduce on Hadoop 1.x clusters has been removed.	Errors	Use clusters that have Hadoop 2.x or higher installed to run MATLAB MapReduce.	Migrate MATLAB MapReduce code that runs on Hadoop 1.x to Hadoop 2.x.

For more information, see Configure a Hadoop Cluster (MATLAB Distributed Computing Server).

R2017a

Access to Intermediate Results and Updates in Parallel Computations: Poll for messages or data from different workers during parallel workflows

You can now transfer intermediate results when you carry out `parfor`, `spmd`, or `parfeval` calculations. Use the `send` and `poll` methods together to transfer and retrieve messages or data from different workers, using a pollable `DataQueue`.

Tall Array Support: Use parallel execution environments for tall timetables and enhanced tall array functions

You can now use the following enhanced `tall` array functions:

- `timetable` supports:

`head`	`join`	`stack`	`unique`
`height`	`ndims`	`standardizeMissing`	`varfun`
`isempty`	`numel`	`table2array`	`width`
`innerjoin`	`size`	`table2cell`	
`ismember`	`sortrows`	`tail`	
`ismissing`	`splitapply`	`topkrows`	

- `array2table`
- `bsxfun`
- `conv`
- `cumsum`, `cumprod`, `cummax`, `cummin`
- `diff`
- `ismember`
- `issorted`, `issortedrows`
- `movmad`, `movmax`, `movmean`, `movmedian`, `movmin`, `movprod`, `movstd`, `movsum`, `movvar`
- `pie` for categoricals
- `repmat`, `repelem`
- `sort`, `sortrows`
- `table2timetable`, `timetable2table`
- `varfun`
- Improved indexing, allowing sorted (ascending or descending) indices in the first dimension

For more information, see Functions That Support Tall Arrays (A–Z).

More Responsive Job Monitor: Automatic updates for new, submitted, or deleted jobs or tasks

You can now use the Job Monitor to get an up-to-date view of your cluster. Verify your changes without manually querying the cluster or forcing an update to the Job Monitor user interface.

Examine your latest changes and execute quickly without interrupting your workflow. For more details, see Job Monitor.

Re-create Jobs: Easily rerun all failed or cancelled tasks

If your job failed or was cancelled, you can now use the `recreate` method to return a new job object. Call `submit` on the new job object to easily rerun all failed or cancelled tasks.

GPU Array Support: Use enhanced gpuArray functions

You can now use the following enhanced `gpuArray` functions:

- `head`, `tail`
- Cubic support for `interp1` and `interp2`
- `movmean`, `movstd`, `movsum`, `movvar`
- `svds`
- `tril` and `triu` for sparse arrays

For more information on this topic, see Run Built-In Functions on a GPU.

Distributed Array Support: Use enhanced distributed array functions

You can now use the following enhanced `distributed` array functions:

- `issymmetric`, `ishermitian`
- `qmr`
- `svds`
- `tfqmr`
- `write` for storing a snapshot of a distributed array in a format suitable for `datastore`
- `mldivide`, providing improved performance for triangular and diagonal systems

For more information, see Using MATLAB Functions on Distributed Arrays.

Simplified Integration for Third-Party Cluster Schedulers: Updates to generic scheduler integration allow folder-based configuration and eliminate the need to specify function handles

You no longer need to specify function handles in your generic scheduler profile. Instead, specify only one folder name and some `AdditionalProperties`, which are similar to name-value pairs. For more information, see Configure for a Generic Scheduler.

MATLAB String Support: Functions in Parallel Computing Toolbox accept MATLAB strings as input

You can now use MATLAB strings for functions in Parallel Computing Toolbox. For information on MATLAB strings, see Create String Arrays (MATLAB).

Support for Spark 2.x enabled Hadoop clusters

Tall array integration on a Spark enabled Hadoop cluster, running MATLAB Distributed Computing Server, now supports both versions 1.x and 2.x.

Upgraded CUDA Toolkit version

The parallel computing products are now using CUDA Toolkit version 8.0. To compile CUDA code for `CUDAKernel` or CUDA MEX-files, you must use toolkit version 8.0.

Discontinued Support for GPU Devices of Compute Capability less than 3.0

In a future release, support for GPU devices of compute capability less than 3.0 will be removed. At that time, a minimum compute capability of 3.0 will be required.

Version History

In R2017a, any use of `gpuDevice` to select a GPU with compute capability less than 3, generates a warning. The device is still supported in this release, but in a future release support will be completely removed for devices with compute capability less than 3.

Backwards Compatibility for MATLAB Job Scheduler: Upgrade MATLAB Job Scheduler clusters, and continue to use previous releases of Parallel Computing Toolbox

You can upgrade your MATLAB Job Scheduler clusters to R2017a and still use the R2016b and R2016a releases of Parallel Computing Toolbox on your MATLAB desktop client to connect to it. This situation only applies to the R2016a release onward. You must maintain an installation of the same release of MATLAB Distributed Computing Server for each release of MATLAB you want to use. The latest MATLAB Job Scheduler routes your jobs accordingly. You can configure MATLAB Job Scheduler with the location of these installations in the `mdce_def` file. For more information, see Install Products and Choose Cluster Configuration.

Upgrade Parallel Computing Products Together

This version of Parallel Computing Toolbox software is accompanied by a corresponding new version of MATLAB Distributed Computing Server software.

Version History

As with every new release, if you are using both parallel computing products, you must upgrade Parallel Computing Toolbox and MATLAB Distributed Computing Server together. These products must be the same version to interact properly with each other.

Jobs created in one version of Parallel Computing Toolbox software do not run in a different version of MATLAB Distributed Computing Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Distributed

Computing Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

Properties of generic cluster objects have changed

The properties of new generic cluster objects have changed.

Version History

From R2017a onwards, you can no longer use the following old properties:

- `CancelJobFcn`
- `CancelTaskFcn`
- `CommunicatingSubmitFcn`
- `DeleteJobFcn`
- `DeleteTaskFcn`
- `GetJobStateFcn`
- `IndependentSubmitFcn`

Instead, set the new `IntegrationScriptsLocation` property to the folder containing your cluster's integration scripts. You must now use integration scripts with the default function name and signature. Specify any additional input arguments to these scripts using the new `AdditionalProperties` property. For more details, see

- Configure for a Generic Scheduler
- Program Communicating Jobs for a Generic Scheduler
- Program Independent Jobs for a Generic Scheduler

Functionality Being Removed or Changed

Functionality	**Result**	**Use Instead**	**Compatibility Considerations**
Support for running MATLAB MapReduce on Hadoop 1.x clusters will be removed in a future release.	Warns	Use clusters that have Hadoop 2.x or higher installed to run MATLAB MapReduce.	Migrate MATLAB MapReduce code that runs on Hadoop 1.x to Hadoop 2.x.

For more information, see "Configure a Hadoop Cluster" (MATLAB Parallel Server).

R2016b

Parallel Support for Tall Arrays: Process big data with tall arrays in parallel on your desktop, MATLAB Distributed Computing Server, and Spark clusters

Speed up your tall array workflows with Parallel Computing Toolbox. You can use Parallel Computing Toolbox to evaluate tall array expressions in parallel using a parallel pool on your desktop. You can also use Parallel Computing Toolbox to scale up tall-array processing by connecting to a parallel pool running on a MATLAB Distributed Computing Server cluster, or to a Spark enabled Hadoop cluster running MATLAB Distributed Computing Server. For more information, see

- Big Data Workflow Using Tall Arrays and Datastores
- Use Tall Arrays on a Parallel Pool
- Use Tall Arrays on a Spark Enabled Hadoop Cluster

Support for GPU Arrays: Use enhanced gpuArray functions, including new sparse iterative solver bicg

- New sparse iterative solver `bicg`
- Support for tolerance set functions: `ismembertol`, `uniquetol`
- Create sparse arrays using `sprandsym`

For more information on this topic, see Run Built-In Functions on a GPU.

Parallel Menu Enhancement: Use the new menu items in the Parallel Menu to configure and manage cloud based resources

Open the Cloud Center web application, and view MATLAB Distributed Computing Server license usage. For more information, see Use Parallel Menu and Cluster Profiles.

New Data Types in Distributed Arrays: Use enhanced functions for creating distributed arrays of: datetime; duration; calendarDuration; string; categorical; and table

Distributed `calendarDuration` Arrays:

`calendarDuration`	`calquarters`	`cellstr`	`time`
`caldays`	`calweeks`	`datevec`	
`calmonths`	`calyears`	`iscalendarduration`	

Distributed `categorical` Arrays:

`categorical`	`iscategorical`	`isundefined`	`setcats`
`addcats`	`iscategory`	`removecats`	
`categories`	`isordinal`	`renamecats`	
`countcats`	`isprotected`	`reordercats`	

Distributed `datetime` Arrays:

`datetime`	`exceltime`	`isweekend`	`string`
`between`	`hms`	`juliandate`	`timeofday`
`cellstr`	`hour`	`minute`	`tzoffset`
`datenum`	`isbetween`	`month`	`week`
`dateshift`	`isdatetime`	`posixtime`	`year`
`datevec`	`isdst`	`quarter`	`ymd`
`day`	`isnat`	`second`	`yyyymmdd`

Distributed `duration` Arrays:

`duration`	`datevec`	`hours`	`minutes`
`cellstr`	`days`	`isduration`	`seconds`
`datenum`	`hms`	`milliseconds`	`years`

Distributed `string` Arrays:

`string`	`erase`	`insertBefore`	`replaceBetween`
`cellstr`	`eraseBetween`	`ismissing`	`reverse`
`compose`	`extractAfter`	`isstring`	`startsWith`
`contains`	`extractBefore`	`lower`	`strip`
`count`	`extractBetween`	`pad`	`strlength`
`endsWith`	`insertAfter`	`replace`	`upper`

Distributed `tables`:

`table`	`istable`	`table2cell`
`head`	`standardizeMissing`	`tail`
`ismissing`	`table2array`	

For more information, see Using MATLAB Functions on Distributed Arrays.

Loading Distributed Arrays: Load distributed arrays in parallel using datastore

Create distributed arrays more easily using `datastore`, and eliminate the need to create distributed arrays with `codistributed`. For more information, see Load Distributed Arrays in Parallel Using datastore.

Cluster Profile Validation: Choose which validation stages run and the number of MATLAB workers to use

In previous releases, validating your cluster profile ran all validation stages and used a fixed number of workers determined from your profile. You can now choose to run a subset of the validation stages and specify the number of workers to use when validating your profile. For more information on the detailed validation steps in your cluster profile, see Validate Cluster Profiles.

Backwards Compatibility: Upgrade MATLAB Job Scheduler clusters, and continue to use the previous release of Parallel Computing Toolbox

You can upgrade your MATLAB Job Scheduler clusters to R2016b and still use the R2016a release of Parallel Computing Toolbox on your MATLAB desktop client to connect to it. This situation only applies to the R2016a release onward. You must maintain an installation of the same release of MATLAB Distributed Computing Server for each release of MATLAB you want to use. The latest MATLAB Job Scheduler will route your jobs accordingly. You can configure MATLAB Job Scheduler with the location of these installations in the `mdce_def` file. For more information, see Install Products and Choose Cluster Configuration.

datetime Support for Timestamps: Use built-in datetime objects in MATLAB to access timestamp information for jobs and tasks

You can now use the following properties for MATLAB jobs:

- `CreateDateTime`
- `SubmitDateTime`
- `StartDateTime`
- `FinishDateTime`

You can use the following properties for MATLAB tasks:

- `CreateDateTime`
- `StartDateTime`
- `FinishDateTime`

For more information, see parallel.Job and parallel.Task

Data Transfer Measurement: Use ticBytes and tocBytes to measure the data transfer between MATLAB workers in a parallel pool

You can now measure how much data needs to be passed around to carry out `parfor`, `spmd` or `parfeval`. Use ticBytes and tocBytes to optimize your code and pass around less data.

Multithreaded Workers: Use multiple computational threads on your MATLAB workers

MATLAB workers used to run in single-threaded mode. Now you can control the number of computational threads so that workers can run in multithreaded mode and use all the cores on your cluster. This enables you to increase the number of computational threads, `NumThreads`, on each worker, without increasing the number of workers, `NumWorkers`. If you have more cores available, increase `NumThreads` to take full advantage of the built-in parallelism provided by the multithreaded nature of many of the underlying MATLAB libraries. For more information, see Create and Modify Cluster Profiles.

Support for Distributed Arrays: Use enhanced distributed array functions, including sparse input to iterative solvers (gmres and lsqr)

- Sparse support for `gmres` and `lsqr`
- Support for `isdiag, istril, istriu, isbanded, bandwidth`, and `mrdivide` for both sparse and dense arrays
- N-dimensional convolutions with `convn`
- `find` now supports the 2-D block-cyclic (2dbc) distribution scheme

For more information, see Using MATLAB Functions on Distributed Arrays.

Increased Data Transfer Limits: Send messages larger than 2 GB using labSend, labSendReceive and labBroadcast

In previous releases, it was not possible to use `labSend, labSendReceive`, or `labBroadcast` to send messages larger than 2GB when the message was not a real dense numeric array (such as a complex array, a sparse array, a cell array or a `struct`). In R2016b, this limitation has been removed.

Upgrade Parallel Computing Products Together

This version of Parallel Computing Toolbox software is accompanied by a corresponding new version of MATLAB Distributed Computing Server software.

Version History

If you are running MATLAB Job Scheduler on your cluster, then you can upgrade MATLAB® Distributed Computing Server without upgrading Parallel Computing Toolbox. However, you cannot upgrade Parallel Computing Toolbox without upgrading MATLAB Distributed Computing Server.

If you are not running MATLAB Job Scheduler, then you must upgrade Parallel Computing Toolbox and MATLAB Distributed Computing Server together. Jobs created in one version of Parallel Computing Toolbox software will not run in a different version of MATLAB Distributed Computing Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Distributed Computing Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

Functionality Being Removed or Changed

Functionality	Result	Use Instead	Compatibility Considerations
Support for running MATLAB MapReduce on Hadoop 1.x clusters will be removed in a future release.	Still runs	Use clusters that have Hadoop 2.x or higher installed to run MATLAB MapReduce.	Migrate MATLAB MapReduce code that runs on Hadoop 1.x to Hadoop 2.x

For more information, see Configure a Hadoop Cluster.

R2016a

GPU Support for Sparse Matrices: Use enhanced gpuArray functions for sparse matrices on GPUs

- Support for 5-argument form of `sparse` constructor
- Support for sparse inputs to `bicgstab` and `pcg`

You can create a sparse gpuArray either by calling `sparse` with a gpuArray input, or by calling `gpuArray` with a sparse input.

For more information on this topic, see Sparse Arrays on a GPU.

Support for Distributed Arrays: Use enhanced distributed array functions including sparse input to direct (mldivide) and iterative solvers (cgs and pcg)

The following functions are new in supporting distributed arrays:

```
cgs
conv
conv2
expint
ischar
pcg
superiorfloat
```

For more details, see MATLAB Functions on Distributed and Codistributed Arrays.

In addition, the following features are new in providing enhanced functionality for distributed arrays:

- Sparse input to `mldivide` (direct system solve)
- Sparse input to `cgs` and `pcg` (iterative system solve)
- Single argument syntax for `sprand` and `sprandn`

GPU-Accelerated Deep Learning: Use Neural Network Toolbox to train deep convolutional neural networks with GPU-enabled acceleration for image classification tasks

For specific information, see the Neural Network Toolbox™ release notes. To access this functionality, Parallel Computing Toolbox is required.

GPU-enabled MATLAB Functions: Accelerate applications using GPU-enabled MATLAB functions for linear equations, descriptive statistics and set operations

The following functions are new in their support for `gpuArrays`:

```
bicg
detrend
discretize
expint
pcg
spconvert
sprand
sprandn
```

New support is available for the ‘rows' option in the following Set Operations:

```
intersect
ismember
setdiff
setxor
union
unique
```

For more details, see Run Built-In Functions on a GPU.

Upgraded CUDA Toolkit version

The parallel computing products are now using CUDA Toolkit version 7.5. To compile CUDA code for `CUDAKernel` or CUDA MEX-files, you must use toolkit version 7.5.

Parallel-Enabled Gradient Estimation: Accelerate more nonlinear solvers in the Optimization Toolbox with parallel finite difference estimation of gradients and Jacobians

Hadoop Kerberos Support: Improved support for Hadoop in a Kerberos authenticated environment

In R2016a, enhanced support for the recommended setup for the Cloudera distribution of Hadoop has been provided.

Transfer unlimited data between client and workers, and attached files up to 4GB in total, in any job using a MATLAB Job Scheduler cluster

In previous releases, the data transfer limit for a MATLAB Job Scheduler cluster was 2GB. In R2016a, this limit has been removed.

matlabpool function removed

`matlabpool` function has been removed. Use `parpool` instead.

Version History

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
`matlabpool`	Errors	`parpool`	In R2016a, `matlabpool` generates the following error: `Undefined function or variable 'ma` In R2015a and R2015b, `matlabpool` generates the following error: `Error using matlabpool. matlabpool` Use `parpool` instead.

Upgrade parallel computing products together

This version of Parallel Computing Toolbox software is accompanied by a corresponding new version of MATLAB Distributed Computing Server software.

Version History

As with every new release, if you are using both parallel computing products, you must upgrade Parallel Computing Toolbox and MATLAB Distributed Computing Server together. These products must be the same version to interact properly with each other.

Jobs created in one version of Parallel Computing Toolbox software will not run in a different version of MATLAB Distributed Computing Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Distributed Computing Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

R2015b

Discontinued support for parallel computing products on 32-bit Windows operating systems

This release of MATLAB products no longer supports 32-bit Parallel Computing Toolbox and MATLAB Distributed Computing Server on Windows operating systems.

Version History

You can no longer install the parallel computing products on 32-bit Windows operating systems. If you must use Windows operating systems for the parallel computing products, upgrade to 64-bit MATLAB products on a 64-bit operating system.

More than 90 GPU-enabled functions in Statistics and Machine Learning Toolbox, including probability distribution, descriptive statistics, and hypothesis testing

Statistics and Machine Learning Toolbox offers enhanced functionality for some of its functions to perform computations on a GPU. For specific information, see the Statistics and Machine Learning Toolbox release notes. Parallel Computing Toolbox is required to access this functionality.

Additional GPU-enabled MATLAB functions, including support for sparse matrices

- "Additional GPU-enabled MATLAB functions" on page 14-2
- "Sparse arrays with GPU-enabled functions" on page 14-2

Additional GPU-enabled MATLAB functions

The following functions are new in their support for gpuArrays:

```
assert                      isbanded                    setxor
bandwidth                   rad2deg                     sortrows
deg2rad                     randperm                    union
expm                        rectint                     unique
gmres                       repelem
intersect                   setdiff
```

In addition to the functions above, the following functions are enhanced in their gpuArray support:

- `arrayfun` now supports code that includes the functions `isfloat`, `isinteger`, `islogical`, `isnumeric`, `isreal`, and `issparse`.
- `pagefun` support for `@mldivide` and `@mrdivide` is no longer limited to 32-by-32 pages.
- `cov`, `max`, `mean`, `median`, `min`, `std`, `sum`, and `var` now support the `'omitnan'` option.
- `accumarray` now supports the logical sparse argument, for generating a sparse gpuArray output.

For a list of MATLAB functions that support gpuArray, see Run Built-In Functions on a GPU.

Sparse arrays with GPU-enabled functions

The following functions are new in their support for sparse gpuArrays:

`abs`
`angle`
`ceil`
`deg2rad`
`expm1`
`fix`
`floor`
`gmres`
`isequal`
`isequaln`
`log1p`
`minus`
`nextpow2`
`plus`
`rad2deg`
`realsqrt`
`round`
`sign`
`spfun`
`sqrt`
`sum`
`uminus`
`uplus`

You can create a sparse gpuArray either by calling `sparse` with a gpuArray input, or by calling `gpuArray` with a sparse input.

For more information on this topic, see Sparse Arrays on a GPU.

mexcuda function for easier compilation of MEX-files containing CUDA code

A new `mexcuda` function allows you to compile MEX-functions for GPU computation.

For more information, see the `mexcuda` function reference page. See also Run CUDA or PTX Code on GPU.

Upgraded CUDA Toolkit version

The parallel computing products are now using CUDA Toolkit version 7.0. To compile CUDA code for CUDAKernel or CUDA MEX-files, you must use toolkit version 7.0.

Scheduler integration scripts for SLURM

This release offers a new set of scripts containing submit and decode functions to support Simple Linux® Utility for Resource Management (SLURM), using the generic scheduler interface. The pertinent code files are in the folder:

```
matlabroot/toolbox/distcomp/examples/integration/slurm
```

where *`matlabroot`* is your installation location.

The `slurm` folder contains a `README` file of instructions, and folders for `shared`, `nonshared`, and `remoteSubmission` network configurations.

For more information, view the files in the appropriate folders. See also Program Independent Jobs for a Generic Scheduler and Program Communicating Jobs for a Generic Scheduler.

parallel.pool.Constant function to create constant data on parallel pool workers, accessible within parallel language constructs such as parfor and parfeval

A new `parallel.pool.Constant` function allows you to define a constant whose value can be accessed by multiple `parfor`-loops or other parallel language constructs (e.g., `spmd` or `parfeval`) without the need to transfer the data multiple times.

For more information and examples, see `parallel.pool.Constant`.

Improved performance of mapreduce on Hadoop 2 clusters

The performance of `mapreduce` running on a Hadoop 2.x cluster with MATLAB Distributed Computing Server is improved in this release for large input data.

Enhanced and additional MATLAB functions for distributed arrays

The following functions are new in supporting distributed arrays, with all forms of codistributor (1-D and 2DBC):

```
bicg                                        rad2deg
deg2rad                                     rectint
polyarea                                    repelem
polyint
```

In addition to the new functions above, the following functions are enhanced in their distributed array support:

- `cov`, `max`, `mean`, `median`, `min`, `std`, `sum`, and `var` now support the `'omitnan'` option.

For a list of MATLAB functions that support distributed arrays, see MATLAB Functions on Distributed and Codistributed Arrays.

Warnings property for tasks

There is a new `Warnings` property for `parallel.Task` objects. This property contains warning information that was issued during execution of the task. The data type is a structure array with the fields `message`, `identifier`, and `stack`. This information is part of the job display in the Command Window and Job Monitor.

More consistent transparency enforcement

For more consistent behavior and results, transparency violations in `parfor`-loops and `spmd` blocks are now being enforced more strictly.

Version History

It is possible that `parfor` or `spmd` code that did not error in previous releases will now generate a transparency violation error. For more information, see Transparency.

Anonymous functions that were saved in a previous release and that reference nested functions will not execute in this release. They will load, but when executed will issue an “Undefined function handle” error.

Upgrade parallel computing products together

This version of Parallel Computing Toolbox software is accompanied by a corresponding new version of MATLAB Distributed Computing Server software.

Version History

As with every new release, if you are using both parallel computing products, you must upgrade Parallel Computing Toolbox and MATLAB Distributed Computing Server together. These products must be the same version to interact properly with each other.

Jobs created in one version of Parallel Computing Toolbox software will not run in a different version of MATLAB Distributed Computing Server software, and might not be readable in different versions of the toolbox software. The job data stored in the folder identified by `JobStorageLocation` (formerly `DataLocation`) might not be compatible between different versions of MATLAB Distributed Computing Server. Therefore, `JobStorageLocation` should not be shared by parallel computing products running different versions, and each version on your cluster should have its own `JobStorageLocation`.

R2015a

Support for mapreduce function on any cluster that supports parallel pools

You can now run parallel `mapreduce` on any cluster that supports a parallel pool. For more information, see Run mapreduce on a Parallel Pool.

Sparse arrays with GPU-enabled functions

This release supports sparse arrays on a GPU. You can create a sparse gpuArray either by calling `sparse` with a gpuArray input, or by calling `gpuArray` with a sparse input. The following functions support sparse gpuArrays.

`classUnderlying`	`isfloat`	`nnz`
`conj`	`isinteger`	`numel`
`ctranspose`	`islogical`	`nzmax`
`end`	`isnumeric`	`real`
`find`	`isreal`	`size`
`full`	`issparse`	`sparse`
`gpuArray.speye`	`length`	`spones`
`imag`	`mtimes`	`transpose`
`isaUnderlying`	`ndims`	
`isempty`	`nonzeros`	

Note the following for some of these functions:

- `gpuArray.speye` is a static constructor method.
- `sparse` supports only single-argument syntax.
- `mtimes` does not support the case of full-matrix times a sparse-matrix.

For more information on this topic, see Sparse Arrays on a GPU.

A new C function, `mxGPUIsSparse`, is available for the MEX interface, to query whether a gpuArray is sparse or not. However, even though the MEX interface can query properties of a sparse gpuArray, its functions cannot access sparse gpuArray elements.

Additional GPU-enabled MATLAB functions

The following functions are new in their support for gpuArrays:

`cdf2rdf`	`istril`	`polyarea`
`gpuArray.freqspace`	`istriu`	`polyder`
`histcounts`	`legendre`	`polyfit`
`idivide`	`nonzeros`	`polyint`
`inpolygon`	`nthroot`	`polyval`
`isdiag`	`pinv`	`polyvalm`
`ishermitian`	`planerot`	
`issymmetric`	`poly`	

Note the following for some of these functions:

- `gpuArray.freqspace` is a static constructor method.

For a list of MATLAB functions that support gpuArray, see Run Built-In Functions on a GPU.

pagefun support for mrdivide and inv functions on GPUs

For gpuArray inputs, `pagefun` is enhanced to support:

- `@inv`
- `@mrdivide` (for square matrix divisors of sizes up to 32-by-32)

Enhancements to GPU-enabled linear algebra functions

Many of the linear algebra functions that support gpuArrays are enhanced for improved performance. Among those functions that can exhibit improved performance are `svd`, `null`, `eig` (for nonsymmetric input), and `mtimes` (for inner products).

Parallel data reads from a datastore with MATLAB partition function

The `partition` function can perform a parallel read and partition of a Datastore. For more information, see `partition` and `numpartitions`. See also Partition a Datastore in Parallel.

Using DNS for cluster discovery

In addition to multicast, the discover cluster functionality of Parallel Computing Toolbox can now use DNS to locate MATLAB Job Scheduler clusters. For information about cluster discovery, see Discover Clusters. For information about configuring and verifying the required DNS SRV record on your network, see DNS SRV Record.

MS-MPI support for local and MATLAB Job Scheduler clusters

On 64-bit Windows platforms, Microsoft MPI (MS-MPI) is now the default MPI implementation for local clusters on the client machine.

For MATLAB Job Scheduler clusters on Windows platforms, you can use MS-MPI by specifying the `-useMSMPI` flag with the `startjobmanager` command.

Ports and sockets in mdce_def file

The following parameters are new to the `mdce_def` file for controlling the behavior of MATLAB Job Scheduler clusters.

- `ALL_SERVER_SOCKETS_IN_CLUSTER` — This parameter controls whether all client connections are outbound, or if inbound connections are also allowed.
- `JOBMANAGER_PEERSESSION_MIN_PORT`, `JOBMANAGER_PEERSESSION_MAX_PORT` — These parameters set the range of ports to use when `ALL_SERVER_SOCKETS_IN_CLUSTER = true`.
- `WORKER_PARALLELPOOL_MIN_PORT`, `WORKER_PARALLELPOOL_MAX_PORT` — These parameters set the range of ports to use on worker machines for parallel pools.

For more information and default settings for these parameters, see the appropriate `mdce_def` file for your platform:

- *`matlabroot`*`\toolbox\distcomp\bin\mdce_def.bat` (Windows)

- *matlabroot*/toolbox/distcomp/bin/mdce_def.sh (UNIX)

Version History

By default in this release, ALL_SERVER_SOCKETS_IN_CLUSTER is true, which makes all connections outbound from the client. For pre-R2015a behavior, set its value to false, which also initiates a set of inbound connections to the client from the MATLAB Job Scheduler and workers.

Improved profiler accuracy for GPU code

The MATLAB profiler now reports more accurate timings for code running on a GPU. For related information, see Measure Performance on the GPU.

Upgraded CUDA Toolkit version

The parallel computing products are now using CUDA Toolkit version 6.5. To compile CUDA code for CUDAKernel or CUDA MEX files, you must use toolkit version 6.5.

Discontinued support for GPU devices on 32-bit Windows computers

This release no longer supports GPU devices on 32-bit Windows machines.

Version History

GPU devices on 32-bit Windows machines are not supported in this release. Instead, use GPU devices on 64-bit machines.

Discontinued support for parallel computing products on 32-bit Windows computers

In a future release, support will be removed for Parallel Computing Toolbox and MATLAB Distributed Computing Server on 32-bit Windows machines.

Version History

Parallel Computing Toolbox and MATLAB Distributed Computing Server are still supported on 32-bit Windows machines in this release, but parallel language commands can generate a warning. In a future release, support will be completely removed for these computers, at which time it will not be possible to install the parallel computing products on them.

matlabpool function removed

The matlabpool function has been removed.

Version History

Calling matlabpool now generates an error. You should instead use parpool to create a parallel pool.

R2014b

Parallelization of mapreduce on local workers

If you have Parallel Computing Toolbox installed, and your default cluster profile specifies a local cluster, then execution of `mapreduce` opens a parallel pool and distributes tasks to the pool workers.

Note If your default cluster profile specifies some other cluster, the `mapreduce` function does not use a parallel pool.

For more information, see Run mapreduce on a Local Cluster.

Additional GPU-enabled MATLAB functions, including accumarray, histc, cummax, and cummin

The following functions are new in their support for gpuArrays:

`accumarray`	`cummax`	`psi`
`acosd`	`cummin`	`rgb2hsv`
`acotd`	`del2`	`roots`
`acscd`	`factorial`	`secd`
`asecd`	`gammainc`	`sind`
`asind`	`gammaincinv`	`sph2cart`
`atan2d`	`gradient`	`subspace`
`atand`	`hankel`	`superiorfloat`
`betainc`	`histc`	`swapbytes`
`betaincinv`	`hsv2rgb`	`tand`
`cart2pol`	`isaUnderlying`	`toeplitz`
`cart2sph`	`median`	`trapz`
`compan`	`mode`	`typecast`
`corrcoef`	`nextpow2`	`unwrap`
`cosd`	`null`	`vander`
`cotd`	`orth`	
`cscd`	`pol2cart`	

Note the following for some of these functions:

- The first input argument to `gammainc` cannot contain any negative elements.

For a list of MATLAB functions that support gpuArray, see Run Built-In Functions on a GPU.

pagefun support for mldivide on GPUs

For gpuArray inputs, `pagefun` is enhanced to support `@mldivide` for square matrix divisors of sizes up to 32-by-32.

Additional MATLAB functions for distributed arrays, including fft2, fftn, ifft2, ifftn, cummax, cummin, and diff

The following functions now support distributed arrays with all forms of codistributor (1-D and 2DBC), or are enhanced in their support for this release:

```
besselh                   erf                        isinteger
besseli                   erfc                       islogical
besselj                   erfcinv                    isnumeric
besselk                   erfcx                      median
bessely                   erfinv                     mode
beta                      fft2                       pol2cart
betainc                   fftn                       psi
betaincinv                gamma                      rgb2hsv
betaln                    gammainc                   sph2cart
cart2pol                  gammaincinv                std
cart2sph                  gammaln                    toeplitz
compan                    hankel                     trapz
corrcoef                  hsv2rgb                    unwrap
cov                       ifft                       vander
cummax                    ifft2                      var
cummin                    ifftn
diff                      isfloat
```

Note the following for some of these functions:

- `isfloat`, `isinteger`, `islogical`, and `isnumeric` now return results based on `classUnderlying` of the distributed array.

For a list of MATLAB functions that support distributed arrays, see MATLAB Functions on Distributed and Codistributed Arrays.

Data Analysis on Hadoop clusters using mapreduce

Parallel Computing Toolbox and MATLAB Distributed Computing Server support the use of Hadoop clusters for the execution environment of `mapreduce` applications. For more information, see:

- Configure a Hadoop Cluster
- Run mapreduce on a Hadoop Cluster

Discover Clusters Supports Microsoft Windows HPC Server for Multiple Releases

The Discover Clusters dialog can now list Microsoft Windows HPC Server clusters for different releases of parallel computing products. For more information about cluster discovery, see Discover Clusters.

For this functionality, the HPC Server client utilities must be installed on the client machine from which you are discovering. See Configure Client Computer for HPC Server.

Upgraded CUDA Toolkit Version

The parallel computing products are now using CUDA Toolkit version 6.0. To compile CUDA code for CUDAKernel or CUDA MEX files, you must use toolkit version 6.0 or earlier.

Discontinued Support for GPU Devices of Compute Capability 1.3

This release no longer supports GPU devices of compute capability 1.3.

Version History

This release supports only GPU devices of compute capability 2.0 or greater.

Discontinued Support for GPU Devices on 32-Bit Windows Computers

In a future release, support for GPU devices on 32-bit Windows machines will be removed.

Version History

GPU devices on 32-bit Windows machines are still supported in this release, but in a future release support will be completely removed for these devices.

R2014a

Number of local workers no longer limited to 12

You can now run a local cluster of more than 12 workers on your client machine. Unless you adjust the cluster profile, the default maximum size for a local cluster is the same as the number of computational cores on the machine.

Additional GPU-enabled MATLAB functions: interp3, interpn, besselj, bessely

The following functions are new in their support for gpuArrays:

```
besselj
bessely
interp3
interpn
```

For a list of MATLAB functions that support gpuArray, see Run Built-In Functions on a GPU.

Additional GPU enabled Image Processing Toolbox functions: bwdist, imreconstruct, iradon, radon

Image Processing Toolbox offers enhanced functionality for some of its functions to perform computations on a GPU. For specific information, see the Image Processing Toolbox release notes. Parallel Computing Toolbox is required to access this functionality.

Enhancements to GPU-enabled MATLAB functions: filter (IIR filters); pagefun (additional functions supported); interp1, interp2, conv2, reshape (performance improvements)

The following functions are enhanced in their support for gpuArray data:

```
conv2                                    rand
filter                                   randi
interp1                                  randn
interp2                                  reshape
pagefun
```

Note the following enhancements for some of these functions:

- `filter` now supports IIR filtering.
- `pagefun` is enhanced to support most element-wise gpuArray functions. Also, these functions are supported: `@ctranspose`, `@fliplr`, `@flipud`, `@mtimes`, `@rot90`, `@transpose`.
- `rand(____,'like',P)` returns a gpuArray of random values of the same underlying class as the gpuArray `P`. This enhancement also applies to `randi`, `randn`.

For a list of MATLAB functions that support gpuArray, see Run Built-In Functions on a GPU.

Duplication of an existing job, containing some or all of its tasks

You can now duplicate job objects, allowing you to resubmit jobs that had finished or failed.

The syntax to duplicate a job is

```
newjob = recreate(oldjob)
```

where `oldjob` is an existing job object. The `newjob` object has all the same tasks and settable properties as `oldjob`, but receives a new `ID`. The old job can be in any state; the new job state is `pending`.

You can also specify which tasks from an existing independent job to include in the new job, based on the task IDs. For example:

```
newjob = recreate(oldjob,'TaskID',[33:48]);
```

For more information, see the `recreate` reference page.

More MATLAB functions enhanced for distributed arrays

The following functions now support distributed arrays with all forms of codistributor (1-D and 2DBC), or are enhanced in their support for this release:

```
eye
ifft
rand
randi
randn
```

Note the following enhancements for some of these functions:

- `ifft` and `randi` are new in support of distributed and codistributed arrays.
- `rand(___,'like',D)` returns a distributed or codistributed array of random values of the same underlying class as the distributed or codistributed array `D`. This enhancement also applies to `randi`, `randn`, and `eye`.

For a list of MATLAB functions that support distributed arrays, see MATLAB Functions on Distributed and Codistributed Arrays.

GPU MEX Support for Updated MEX

The GPU MEX support for CUDA code now incorporates the latest MATLAB MEX functionality. See Streamlined MEX compiler setup and improved troubleshooting.

Version History

The latest MEX does not support the `mexopts` files shipped in previous releases. Updated `.xml` files are provided instead. To use the updated MEX functionality and to avoid a warning, replace the `mexopts` file you used in past releases with the appropriate new `.xml` file as described in Set Up for MEX-File Compilation.

Old Programming Interface Removed

The programming interface characterized by distributed jobs and parallel jobs has been removed. This old interface used functions such as `findResource`, `createParallelJob`, `getAllOutputArguments`, `dfeval`, etc.

Version History

The functions of the old programming interface now generate errors. You must migrate your code to the interface described in the R2012a release topic “New Programming Interface” on page 21-2.

matlabpool Function Being Removed

The `matlabpool` function is being removed.

Version History

Calling `matlabpool` continues to work in this release, but now generates a warning. You should instead use `parpool` to create a parallel pool.

Removed Support for parallel.cluster.Mpiexec

Support for clusters of type parallel.cluster.Mpiexec has been removed.

Version History

Any attempt to use parallel.cluster.Mpiexec clusters now generates an error. As an alternative, consider using the generic scheduler interface, parallel.cluster.Generic.

R2013b

parpool: New command-line interface (replaces matlabpool), desktop indicator, and preferences for easier interaction with a parallel pool of MATLAB workers

Parallel Pool

Replaces MATLAB Pool

Parallel pool syntax replaces MATLAB pool syntax for executing parallel language constructs such as `parfor`, `spmd`, `Composite`, and `distributed`. The pool is represented in MATLAB by a parallel.Pool object.

The general workflow for these parallel constructs remains the same: When the pool is available, `parfor`, `spmd`, etc., run the same as before. For example:

MATLAB Pool	Parallel Pool

`matlabpool open 4`
`parfor ii=1:n`
`    X(n) = myFun(n);`
`end`
`matlabpool close`
	`p = parpool(4)`
	`parfor ii=1:n`
	`    X(n) = myFun(n);`
	`end`
	`delete(p)`

Functions for Pool Control

The following functions provide command-line interface for controlling a parallel pool. See the reference pages for more information about each.

Function	Description
`parpool`	Start a parallel pool
`gcp`	Get current parallel pool or start pool
`delete`	Shut down and delete the parallel pool
`addAttachedFiles`	Attach files to the parallel pool
`listAutoAttachedFiles`	List files automatically attached to the parallel pool
`updateAttachedFiles`	Send updates to files already attached to the parallel pool

Asynchronous Function Evaluation on Parallel Pool

You can evaluate functions asynchronously on one or all workers of a parallel pool. Use `parfeval` to evaluate a function on only one worker, or use `parfevalOnAll` to evaluate a function on all workers in the pool.

`parfeval` or `parfevalOnAll` returns an object called a *future*, from which you can get the outputs of the asynchronous function evaluation. You can create an array of futures by calling `parfeval` in a `for`-loop, setting unique parameters for each call in the array.

The following table lists the functions for submitting asynchronous evaluations to a parallel pool, retrieving results, and controlling future objects. See the reference page of each for more details.

Function	Description
`parfeval`	Evaluate function asynchronously on worker in parallel pool
`parfevalOnAll`	Evaluate function asynchronously on all workers in parallel pool
`fetchOutputs`	Retrieve all output arguments from future
`fetchNext`	Retrieve next available unread future outputs
`cancel`	Cancel queued or running future
`wait`	Wait for future to complete

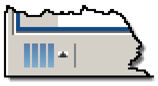
For more information on parallel future objects, including their methods and properties, see the parallel.Future reference page.

Version History

This release continues to support MATLAB pool language usage, but this support might discontinue in future releases. You should update your code as soon as possible to use parallel pool syntax instead.

New Desktop Pool Indicator

A new icon at the lower-left corner of the desktop indicates the current pool status.



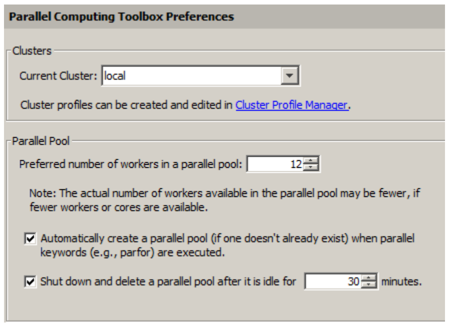
Icon color and tool tips let you know if the pool is busy or ready, how large it is, and when it might time out. You can click the icon to start a pool, stop a pool, or access your parallel preferences.

New Parallel Preferences

Your MATLAB preferences now include a group of settings for parallel preferences. These settings control general behavior of clusters and parallel pools for your MATLAB session.

You can access your parallel preferences in these ways:

- In the **Environment** section of the **Home** tab, click **Parallel > Parallel Preferences**
- Click the desktop pool indicator icon, and select **Parallel preferences**.
- Type `preferences` at the command line, and click the Parallel Computing Toolbox node.



Parallel Computing Toolbox Preferences

Clusters

Current Cluster: local

Cluster profiles can be created and edited in Cluster Profile Manager.

Parallel Pool

Preferred number of workers in a parallel pool: 12

Note: The actual number of workers available in the parallel pool may be fewer, if fewer workers or cores are available.

✓ Automatically create a parallel pool (if one doesn't already exist) when parallel keywords (e.g., parfor) are executed.

✓ Shut down and delete a parallel pool after it is idle for 30 minutes.

Settings in your parallel preferences control the default cluster choice, and the preferred size, automatic opening, and timeout conditions for parallel pools. For more information about these settings, see Parallel Preferences.

Automatic start of a parallel pool when executing code that uses parfor or spmd

You can set your parallel preferences so that a parallel pool automatically starts whenever you execute a language construct that runs on a pool, such as `parfor`, `spmd`, `Composite`, `distributed`, `parfeval`, and `parfevalOnAll`.

Version History

The default preference setting is to automatically start a pool when a parallel language construct requires it. If you want to make sure a pool does not start automatically, you must change your parallel preference setting. You can also work around this by making sure to explicitly start a parallel pool with `parpool` before encountering any code that needs a pool.

By default, a parallel pool will shut down *if idle for 30 minutes.* To prevent this, change the setting in your parallel preferences; or the pool indicator tool tip warns of an impending timeout and provides a link to extend it.

Option to start a parallel pool without using MPI

You now have the option to start a parallel pool on a local or MATLAB Job Scheduler cluster so that the pool does not support running SPMD constructs. This allows the parallel pool to keep running even if one or more workers aborts during `parfor` execution. You explicitly disable SPMD support when starting the parallel pool by setting its `'SpmdEnabled'` property `false` in the call to the `parpool` function. For example:

```
p = parpool('SpmdEnabled',false);
```

Version History

Running any code (including MathWorks toolbox code) that uses SPMD constructs, on a parallel pool that was created without SPMD support, will generate errors.

More GPU-enabled MATLAB functions (e.g., interp2, pagefun) and Image Processing Toolbox functions (e.g., bwmorph, edge, imresize, and medfilt2)

Image Processing Toolbox offers enhanced functionality for some of its functions to perform computations on a GPU. For specific information, see the Image Processing Toolbox release notes. Parallel Computing Toolbox is required to access this functionality.

The following functions are new or enhanced in Parallel Computing Toolbox to support gpuArrays:

```
flip
interp2
pagefun
```

Note the following for some of these functions:

- `pagefun` allows you to iterate over the pages of a gpuArray, applying `@mtimes` to each page.

  For more information, see the `pagefun` reference page, or type `help pagefun`.

For complete lists of functions that support gpuArray, see Run Built-In Functions on a GPU.

More MATLAB functions enabled for distributed arrays: permute, ipermute, and sortrows

The following functions now support distributed arrays with all forms of codistributor (1-D and 2DBC), or are enhanced in their support for this release:

```
ipermute                                  zeros
permute                                   ones
sortrows                                  nan
                                          inf
cast                                      true
                                          false
```

Note the following enhancements for some of these functions:

- `ipermute`, `permute`, and `sortrows` support distributed arrays for the first time in this release.
- `cast` supports the `'like'` option for distributed arrays, applying the underlying class of one array to another.
- `Z = zeros(___,'like',P)` returns a distributed array of zeros of the same complexity as distributed array `P`, and same underlying class as `P` if class is not specified in the function call. The same behavior applies to the other similar constructors in the right-hand column of this table.

For more information on any of these functions, type `help distributed.`*`functionname`*. For example:

```
help distributed.ipermute
```

For complete lists of MATLAB functions that support distributed arrays, see MATLAB Functions on Distributed and Codistributed Arrays.

Enhancements to MATLAB functions enabled for GPUs, including ones, zeros

The following functions are enhanced in their support for gpuArray data:

```
zeros                                     eye
ones                                      true
nan                                       false
inf
                                          cast
```

Note the following enhancements for these functions:

- `Z = zeros(___,'like',P)` returns a gpuArray of zeros of the same complexity as gpuArray `P`, and same underlying class as `P` if class is not specified. The same behavior applies to the other constructor functions listed in this table.

- `cast` also supports the `'like'` option for gpuArray input, applying the underlying class of one array to another.

For more information on any of these functions, type `help gpuArray.`*`functionname`*. For example:

```
help gpuArray.cast
```

For complete lists of MATLAB functions that support gpuArray, see Run Built-In Functions on a GPU.

gputimeit Function to Time GPU Computations

`gputimeit` is a new function to measure the time to run a function on a GPU. It is similar to the MATLAB function `timeit`, but ensures accurate time measurement on the GPU. For more information and examples, see the `gputimeit` reference page.

New GPU Random Number Generator NormalTransform Option: Box-Muller

When generating random numbers on a GPU, there is a new option for `'NormalTransform'` called `'BoxMuller'`. The Box-Muller transform allows faster generation of normally distributed random numbers on the GPU.

This new option is the default `'NormalTransform'` setting when using the `Philox4x32-10` or `Threefry4x64-20` generator. The following commands, therefore, use `'BoxMuller'` for `'NormalTransform'`:

```
parallel.gpu.rng(0,'Philox4x32-10')
parallel.gpu.rng(0,'Threefry4x64-20')
```

Note The `'BoxMuller'` option is not supported for the `CombRecursive` (`mrg32k3a`) generator

Version History

In previous releases, the default `'NormalTransform'` setting when using the `Philox4x32-10` or `Threefry4x64-20` generator on a GPU was `'Inversion'`. If you used either of these generators with the default `'NormalTranform'` and you want to continue with the same behavior, you must explicitly set the `'NormalTransform'` with either of these commands:

```
stream = parallel.gpu.RandStream('Philox4x32-10','NormalTransform','Inversion')
parallel.gpu.RandStream.setGlobalStream(stream)

stream = parallel.gpu.RandStream('Threefry4x64-20','NormalTransform','Inversion')
parallel.gpu.RandStream.setGlobalStream(stream)
```

Upgraded MPICH2 Version

The parallel computing products are now shipping MPICH2 version 1.4.1p1 on all platforms.

Version History

If you use your own MPI builds, you might need to create new builds compatible with this latest version, as described in Use Different MPI Builds on UNIX Systems.

Discontinued Support for GPU Devices of Compute Capability 1.3

In a future release, support for GPU devices of compute capability 1.3 will be removed. At that time, a minimum compute capability of 2.0 will be required.

Version History

In R2013b, any use of `gpuDevice` to select a GPU with compute capability 1.3, generates a warning. The device is still supported in this release, but in a future release support will be completely removed for these 1.3 devices.

Discontinued Support for parallel.cluster.Mpiexec

Support for clusters of type parallel.cluster.Mpiexec is being discontinued.

Version History

In R2013b, any use of parallel.cluster.Mpiexec clusters generates a warning. In a future release, support will be completely removed.

R2013a

GPU-enabled functions in Image Processing Toolbox and Phased Array System Toolbox

More toolboxes offer enhanced functionality for some of their functions to perform computations on a GPU. For specific information about these other toolboxes, see their respective release notes. Parallel Computing Toolbox is required to access this functionality.

More MATLAB functions enabled for use with GPUs, including interp1 and ismember

The following functions are enhanced to support gpuArray data:

```
interp1                  ismember
isfloat                  isnumeric
isinteger
```

Note the following for some of these functions:

- `interp1` supports only the linear and nearest interpolation methods.
- `isfloat`, `isinteger`, and `isnumeric` now return results based on `classUnderlying` of the gpuArray.
- `ismember` does not support the `'rows'` or `'legacy'` option for gpuArray input.

For complete lists of functions that support gpuArray, see Built-In Functions That Support gpuArray.

Enhancements to MATLAB functions enabled for GPUs, including arrayfun, svd, and mldivide (\)

The following functions are enhanced in their support for gpuArray data:

```
arrayfun                 mrdivide
bsxfun                   svd
mldivide
```

Note the following enhancements for some of these functions:

- `arrayfun` and `bsxfun` support indexing and accessing variables of outer functions from within nested functions.
- `arrayfun` supports singleton expansion of all arguments for all operations. For more information, see the `arrayfun` reference page.
- `mldivide` and `mrdivide` support all rectangular arrays.
- `svd` can perform economy factorizations.

For complete lists of MATLAB functions that support gpuArray, see Built-In Functions That Support gpuArray.

Ability to launch CUDA code and manipulate data contained in GPU arrays from MEX-functions

You can now compile MEX-files that contain CUDA code, to create functions that support gpuArray input and output. This functionality is supported only on 64-bit platforms (win64, glnxa64, maci64). For more information and examples, see Execute MEX-Functions Containing CUDA Code.

For a list of C functions supporting this capability, see the group of C Functions in GPU Computing.

Automatic detection and transfer of files required for execution in both batch and interactive workflows

Parallel Computing Toolbox can now automatically attach files to a job so that workers have the necessary code files for evaluating tasks. When you set a job object's `AutoAttachFiles` to true, an analysis determines what files on the client machine are necessary for the evaluation of your job, and those files are automatically attached to the job and sent to the worker machines.

You can set the `AutoAttachFiles` property in the Cluster Profile Manager, or at the command-line. To get a listing of the files that are automatically attached, use the `listAutoAttachedFiles` method on a job or task object.

For more information, see Pass Data to and from Worker Sessions.

If the `AutoAttachFiles` property in the cluster profile for the MATLAB pool is set to `true`, MATLAB performs an analysis on `spmd` blocks and `parfor`-loops to determine what code files are necessary for their execution, then automatically attaches those files to the MATLAB pool job so that the code is available to the workers.

When you use the MATLAB editor to update files on the client that are attached to a `matlabpool`, those updates are automatically propagated to the workers in the pool.

More MATLAB functions enabled for distributed arrays

The following functions now support distributed arrays with all forms of codistributor (1-D and 2DBC), or are enhanced in their support for this release:

```
cumprod                   qr
cumsum                    prod
eig
```

Note the following enhancements for some of these functions:

- `eig` supports generalized eigenvalues for symmetric matrices.
- `qr` supports column pivoting.
- `cumprod`, `cumsum`, and `prod` now support all integer data types; and `prod` accepts the optional `'native'` or `'double'` argument.

R2012b

More MATLAB functions enabled for GPUs, including convn, cov, and normest

- “gpuArray Support” on page 20-2
- “MATLAB Code on the GPU” on page 20-2

gpuArray Support

The following functions are enhanced to support gpuArray data, or are expanded in their support:

```
bitget                    cov                          normest
bitset                    issparse                     pow2
cond                      mpower                       var
convn                     nnz
```

The following functions are not methods of the gpuArray class, but they now work with gpuArray data:

```
blkdiag                   ismatrix                     isvector
cross                     isrow                        std
iscolumn
```

For complete lists of functions that support gpuArray, see Built-In Functions That Support gpuArray.

MATLAB Code on the GPU

`bsxfun` now supports the same subset of the language on a GPU that `arrayfun` does.

GPU support is extended to include the following MATLAB code in functions called by `arrayfun` and `bsxfun` to run on the GPU:

```
bitget
bitset
pow2
```

GPU-enabled functions in Neural Network Toolbox, Phased Array System Toolbox, and Signal Processing Toolbox

A number of other toolboxes now support enhanced functionality for some of their functions to perform computations on a GPU. For specific information about these other toolboxes, see their respective release notes. Parallel Computing Toolbox is required to access this functionality.

Performance improvements to GPU-enabled MATLAB functions and random number generation

The performance of some MATLAB functions and random number generation on GPU devices is improved in this release.

You now have a choice of three random generators on the GPU: the combined multiplicative recursive MRG32K3A, the Philox4x32-10, and the Threefry4x64-20. For information on these generators and how to select them, see Control the Random Stream for gpuArray. For information about generating random numbers on a GPU, and a comparison between GPU and CPU generation, see Control Random Number Streams.

Automatic detection and selection of specific GPUs on a cluster node when multiple GPUs are available on the node

When multiple workers run on a single compute node with multiple GPU devices, the devices are automatically divided up among the workers. If there are more workers than GPU devices on the node, multiple workers share the same GPU device. If you put a GPU device in `'exclusive'` mode, only one worker uses that device. As in previous releases, you can change the device used by any particular worker with the `gpuDevice` function.

More MATLAB functions enabled for distributed arrays, including sparse constructor, bsxfun, and repmat

The following functions now support distributed arrays with all forms of codistributor (1-D and 2DBC), or are enhanced in their support for this release:

`atan2d`	`mrdivide`	`struct2cell`
`bsxfun`	`repmat`	`typecast`
`cell2struct`	`sparse`	

Note the following enhancements for some of these functions:

- `cell2struct`, `struct2cell`, and `typecast` now support 2DBC in addition to 1-D distribution.
- `mrdivide` is now fully supported, and is no longer limited to accepting only scalars for its second argument.
- `sparse` is now fully supported for all distribution types.

This release also offers improved performance of fft functions for long vectors as distributed arrays.

Detection of MATLAB Distributed Computing Server clusters that are available for connection from user desktops through Profile Manager

You can let MATLAB discover clusters for you. Use either of the following techniques to discover those clusters which are available for you to use:

- On the **Home** tab in the **Environment** section, click **Parallel > Discover Clusters**.
- In the Cluster Profile Manager, click **Discover Clusters**.

For more information, see Discover Clusters.

gpuArray Class Name

The object type formerly known as a GPUArray has been renamed to gpuArray. The corresponding class name has been changed from parallel.gpu.GPUArray to the shorter gpuArray. The name of the function `gpuArray` remains unchanged.

Version History

You cannot load gpuArray objects from files that were saved in previous versions.

Code that uses the old class name must be updated to use the shorter new name. For example, the functions for directly generating gpuArrays on the GPU:

Previous version form	New version form

`parallel.gpu.GPUArray.rand`
`parallel.gpu.GPUArray.ones`
 	
etc.
	`gpuArray.rand`
	`gpuArray.ones`
	
	etc.

Diary Output Now Available During Running Task

Diary output from tasks (including those of batch jobs) can now be obtained while the task is still running. The diary is text output that would normally be sent to the Command Window. Now this text is appended to the task’s `Diary` property as the text is generated, rather than waiting until the task is complete. You can read this property at any time. Diary information is accumulated only if the job’s `CaptureDiary` property value is `true`. (**Note**: This feature is not yet available for SOA jobs on HPC Server clusters.)

R2012a

New Programming Interface

This release provides a new programming interface for accessing clusters, jobs, and tasks.

General Concepts and Phrases

This table maps some of the concepts and phrases from the old interface to the new.

Previous Interface	New Interface in R2012a
MathWorks job manager	MATLAB Job Scheduler
Third-party or local scheduler	Common job scheduler (CJS)
Configuration	Profile
Scheduler	Cluster

The following code examples compare programming the old and new interfaces, showing some of the most common commands and properties. Note that most differences involve creating a cluster object instead of a scheduler object, and some of the property and method names on the job. After the example are tables listing some details of these new objects.

Previous Interface	New Interface
`sched = findResource('scheduler',...`	`clust = parcluster('local');`
`        'Configuration','local');`	
`j = createJob(sched,...`	`j = createJob(clust,...`
`    'PathDependencies',{'/share/app/'},...`	`    'AdditionalPaths',{'/share/app/'}),...`
`    'FileDependencies',{'funa.m','funb.m'};`	`    'AttachedFiles,{'funa.m','funb.m'};`
`createTask(j,@myfun,1,{3,4});`	`createTask(j,@myfun,1,{3,4});`
`submit(j);`	`submit(j);`
`waitForState(j);`	`wait(j);`
`results = j.getAllOutputArguments;`	`results = j.fetchOutputs;`

Objects

These tables compare objects in the previous and new interfaces.

Previous Scheduler Objects	New Cluster Objects
`ccsscheduler`	`parallel.cluster.HPCServer`
`genericscheduler`	`parallel.cluster.Generic`
`jobmanager`	`parallel.cluster.MJS`
`localscheduler`	`parallel.cluster.Local`
`lsfscheduler`	`parallel.cluster.LSF`
`mpiexec`	`parallel.cluster.Mpiexec`
`pbsproscheduler`	`parallel.cluster.PBSPro`
`torquescheduler`	`parallel.cluster.Torque`

For information on each of the cluster objects, see the `parallel.Cluster` reference page.

Previous Job Objects	New Job Objects
`job` (distributed job)	`parallel.job.MJSIndependentJob`

Previous Job Objects	New Job Objects
`matlabpooljob`	`parallel.job.MJSCommunicatingJob` where (`'Type' = 'Pool'`)
`paralleljob`	`parallel.job.MJSCommunicatingJob` where (`'Type' = 'SPMD'`)
`simplejob`	`parallel.job.CJSIndependentJob`
`simplematlabpooljob`	`parallel.job.CJSCommunicatingJob` (`'Type' = 'Pool'`)
`simpleparalleljob`	`parallel.job.CJSCommunicatingJob` (`'Type' = 'SPMD'`)

For information on each of the job objects, see the `parallel.Job` reference page.

Previous Task Objects	New Task Objects
`task`	`parallel.task.MJSTask`
`simpletask`	`parallel.task.CJSTask`

For information on each of the task objects, see the `parallel.Task` reference page.

Previous Worker Object	New Worker Objects
`worker`	`parallel.cluster.MJSWorker`, `parallel.cluster.CJSWorker`

For information on each of the worker objects, see the `parallel.Worker` reference page.

Functions and Methods

This table compares some functions and methods of the old interface to those of the new. Many functions do not have a name change in the new interface, and are not listed here. Not all functions are available for all cluster types.

Previous Name	New Name
`findResource`	`parcluster`
`createJob`	`createJob` (no change)
`createParallelJob`	`createCommunicatingJob` (where `'Type' = 'SPMD'`)
`createMatlabPoolJob`	`createCommunicatingJob` (where `'Type' = 'Pool'`)
`destroy`	`delete`
`clearLocalPassword`	`logout`
`createTask`	`createTask` (no change)
`getAllOutputArguments`	`fetchOutputs`
`getJobSchedulerData`	`getJobClusterData`
`setJobSchedulerData`	`setJobClusterData`

Previous Name	New Name
`getCurrentJobmanager`	`getCurrentCluster`
`getFileDependencyDir`	`getAttachedFilesFolder`

Properties

In addition to a few new properties on the objects in the new interface, some other properties have new names when using the new interface, according to the following tables.

Previous Scheduler Properties	New Cluster Properties
`DataLocation`	`JobStorageLocation`
`Configuration`	`Profile`
`HostAddress`	`AllHostAddresses`
`Computer`	`ComputerType`
`ClusterOsType`	`OperatingSystem`
`IsUsingSecureCommunication`	`HasSecureCommunication`
`SchedulerHostname`, `MasterName`, `Hostname`	`Host`
`ParallelSubmissionWrapperScript`	`CommunicatingJobWrapper`
`ClusterSize`	`NumWorkers`
`NumberOfBusyWorkers`	`NumBusyWorkers`
`NumberOfIdleWorkers`	`NumIdleWorkers`
`SubmitFcn`	`IndependentSubmitFcn`
`ParallelSubmitFcn`	`CommunicatingSubmitFcn`
`DestroyJobFcn`	`DeleteJobFcn`
`DestroyTaskFcn`	`DeleteTaskFcn`

Previous Job Properties	New Job Properties
`FileDependencies`	`AttachedFiles`
`PathDependencies`	`AdditionalPaths`
`MinimumNumberOfWorkers`, `MaximumNumberOfWorkers`	`NumWorkersRange`

Previous Task Properties	New Task Properties
`MaximumNumberOfRetries`	`MaximumRetries`

Getting Help

In addition to these changes, there are some new properties and methods, while some old properties are not used in the new interface. For a list of the methods and properties available for clusters, jobs, and tasks, use the following commands for help on each class type:

```
help parallel.Cluster
help parallel.Job
help parallel.Task

help parallel.job.CJSIndependentJob
help parallel.job.CJSCommunicatingJob
help parallel.task.CJSTask

help parallel.job.MJSIndependentJob
help parallel.job.MJSCommunicatingJob
help parallel.task.MJSTask
```

There might be slight changes in the supported format for properties whose names are still the same. To get help on an individual method or property, the general form of the command is:

```
help parallel.obj-type.method-or-property-name
```

You might need to specify the subclass in some cases, for example, where different cluster types use properties differently. The following examples display the help for specified methods and properties of various object types:

```
help parallel.cluster.LSF.JobStorageLocation
help parallel.Job.fetchOutputs
help parallel.job.MJSIndependentJob.FinishedFcn
help parallel.Task.delete
```

Version History

Jobs

This release still supports the old form of interface, however, the old interface and the new interface are not compatible in the same job. For example, a job manager scheduler object that you create with `findResource` requires that you use only the old interface methods and properties, and cannot be used for creating a communicating job (`createCommunicatingJob`). A cluster that was defined with `parcluster` must use the new interface, and cannot be used to create a parallel job (`createParallelJob`).

Graphical interfaces provide access only to the new interface. The Configurations Manager is no longer available and is replaced by the Cluster Profile Manager. Actions that use profiles automatically convert and upgrade your configurations to profiles. Therefore, if you already have a group of configurations, the first time you open the Cluster Profile Manager, it should already be populated with your converted profiles. Furthermore, you can specify cluster profiles when using the old interface in places where configurations are expected.

One job manager (or MATLAB Job Scheduler) can accommodate jobs of both the old and new interface at the same time.

Creating and Finding Jobs and Tasks

In the old interface, to create or find jobs or tasks, you could specify property name and value pairs in structures or cell arrays, and then provide the structure or cell array as an input argument to the function you used. In the new interface, property names and values must be pairs of separate arguments, with the property name as a string expression and its value of the appropriate type. This applies to the functions `createJob`, `createCommunicatingJob`, `createTask`, `findJob`, and `findTask`.

Batch

Jobs created by the `batch` command use the new interface, even if you specify configurations or properties using the old interface. For example, the following code generates two identical jobs of the new interface, even though job `j2` is defined with an old interface property. The script `randScript` contains just the one line of code, `R = rand(3)`, and the default profile is `local`.

```
j1 = batch('randScript','AdditionalPaths','c:\temp');
j1.wait;
R1 = j1.load('R');
```

or

```
j2 = batch('randScript','PathDependencies','c:\temp');
j2.wait;
R2 = j2.load('R');
```

```
 whos
  Name      Size      Bytes  Class

  R1        1x1         248  struct
  R2        1x1         248  struct
  j1        1x1         112  parallel.job.CJSIndependentJob
  j2        1x1         112  parallel.job.CJSIndependentJob
```

Communicating Job Wrapper

In the old interface, for a parallel job in an LSF, TORQUE, or PBS Pro scheduler, you would call the scheduler's `setupForParallelExecution` method with the necessary arguments so that the toolbox could automatically set the object's `ClusterOSType` and `ParallelSubmissionWrapperScript` properties, thus determining which wrapper was used. In the new interface, with a communicating job you only have to set the LSF, Torque, or PBSPro cluster object's `OperatingSystem` and `CommunicatingJobWrapper` properties, from which the toolbox calculates which wrapper to use. For more information about these properties and their possible values, in MATLAB type

```
 help parallel.cluster.LSF.CommunicatingJobWrapper
```

You can change the `LSF` to `PBSPro` or `Torque` in this command, as appropriate.

Enhanced Example Scripts

An updated set of example scripts is available in the product for using a generic scheduler with the new programming interface. These currently supported scripts are provided in the folder:

`matlabroot``/toolbox/distcomp/examples/integration`

For more information on these scripts and their updates, see the `README` file provided in each subfolder, or see Supplied Submit and Decode Functions.

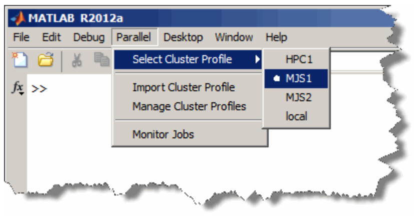
Version History

Scripts that use the old programming interface are provided in the folder *`matlabroot`*`/toolbox/distcomp/examples/integration/old`. The scripts that resided in this folder in previous releases are no longer available. The scripts currently in this folder might be removed in future releases.

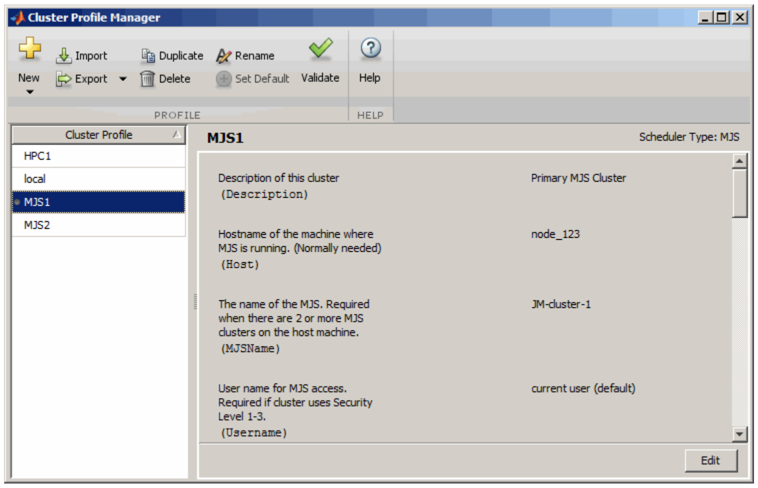
Cluster Profiles

New Cluster Profile Manager

Cluster profiles replace parallel configurations for defining settings for clusters and their jobs. You can access profiles and the Cluster Profile Manager from the desktop **Parallel** menu. From this menu you can select or import profiles. To choose a profile as the default, select the desktop menu **Parallel** > **Select Cluster Profile**. The current default profile is indicated with a bold dot.



The Cluster Profile Manager lets you create, edit, validate, import, and export profiles, among other actions. To open the Cluster Profile Manager, select **Parallel** > **Manage Cluster Profiles**.



MJS1 Scheduler Type: MJS

Description of this cluster (Description)	Primary MJS Cluster
Hostname of the machine where MJS is running. (Normally needed) (Host)	node_123
The name of the MJS. Required when there are 2 or more MJS clusters on the host machine. (MJSName)	JM-cluster-1
User name for MJS access. Required if cluster uses Security Level 1-3. (Username)	current user (default)

For more information about cluster profiles and the Cluster Profile Manager, see Cluster Profiles.

Programming with Profiles

These commands provide access to profiles and the ability to create cluster objects.

Function	Description
`p = parallel.clusterProfiles`	List of your profiles
`parallel.defaultClusterProfile`	Specifies which profile to use by default
`c = parcluster('clustername')`	Creates cluster object, `c`, for accessing parallel compute resources
`c.saveProfile`	Saves changes of cluster property values to its current profile

Function	Description
`c.saveAsProfile`	Saves cluster properties to a profile of the specified name, and sets that as the current profile for this cluster
`parallel.importProfile`	Import profiles from specified `.settings` file
`parallel.exportProfile`	Export profiles to specified `.settings` file

Profiles in Compiled Applications

Because compiled applications include the current profiles of the user who compiles, in most cases the application has the profiles it needs. When other profiles are needed, a compiled application can also import profiles that have been previously exported to a `.settings` file. The new `ParallelProfile` key supports exported parallel configuration `.mat` files and exported cluster profile `.settings` files; but this might change in a future release. For more information, see Export Profiles for MATLAB Compiler.

Version History

In past releases, when a compiled application imported a parallel configuration, that configuration would overwrite a configuration of the same if it existed. In this release, imported profiles are renamed if profiles already exist with the same name; so the same profile might have a different name in the compiled application than it does in the exported profile file.

Enhanced GPU Support

GPUArray Support

The following functions are added to those that support GPUArray data, or are enhanced in their support for this release:

```
beta                      ifft                        mldivide
betaln                    ifft2                       min
bsxfun                    ifftn                       mrdivide
circshift                 ind2sub                     norm
det                       int2str                     num2str
eig                       inv                         permute
fft                       ipermute                    qr
fft2                      isequaln                    shiftdim
fftn                      issorted                    sprintf
fprintf                   mat2str                     sub2ind
full                      max
```

Note the following enhancements and restrictions to some of these functions:

- GPUArray usage now supports all data types supported by MATLAB, except `int64` and `uint64`.
- For the list of functions that `bsxfun` supports, see the `bsxfun` reference page.
- The full range of syntax is now supported for `fft`, `fft2`, `fftn`, `ifft`, `ifft2`, and `ifftn`.
- `eig` now supports all matrices, symmetric or not.
- `issorted` supports only vectors, not matrices.
- `max` and `min` can now return two output arguments, including an index vector.

- `mldivide` supports complex arrays. It also supports overdetermined matrices (with more rows than columns), with no constraints on the second input.
- `mrdivide` supports underdetermined matrices (more columns than rows) as the second input argument.
- `norm` now supports the form `norm(X,2)`, where `X` is a matrix.

The following functions are not methods of the GPUArray class, but they do work with GPUArray data:

`angle`	`ifftshift`	`rank`
`fliplr`	`kron`	`squeeze`
`flipud`	`mean`	`rot90`
`flipdim`	`perms`	`trace`
`fftshift`		

Reset or Deselect GPU Device

Resetting a GPU device clears your GPUArray and CUDAKernel data from the device. There are two ways to reset a GPU device, while still keeping it as the currently selected device. You can use the `reset` function, or you can use `gpuDevice(idx)` with the current device's index for `idx`. For example, use `reset`:

```
idx = 1
g = gpuDevice(idx)
reset(g)
```

Alternatively, call `gpuDevice` again with the same index argument:

```
idx = 1
g = gpuDevice(idx)
.
.
.
g = gpuDevice(idx)  % Resets GPU device, clears data
```

To deselect the current device, use `gpuDevice([ ])` with an empty argument (as opposed to no argument). This clears the GPU of all arrays and kernels, and invalidates variables in the workspace that point to such data.

Asynchronous GPU Calculations and Wait

All GPU calculations now run asynchronously with MATLAB. That is, when you initiate a calculation on the GPU, MATLAB continues execution while the GPU runs its calculations at the same time. The `wait` command now accommodates a GPU device, so that you can synchronize MATLAB and the GPU. The form of the command is

```
wait(gpudev)
```

where `gpudev` is the object representing the GPU device to wait for. At this command, MATLAB waits until all current calculations complete on the specified device.

Version History

In previous releases, MATLAB and the GPU were synchronous, so that any calls to the GPU had to complete before MATLAB proceeded to the next command. This is no longer the case. Now MATLAB continues while the GPU is running. The `wait` command lets you time GPU code execution.

Verify GPUArray or CUDAKernel Exists on the Device

The new function `existsOnGPU` lets you verify that a GPUArray or CUDAKernel exists on the current GPU device, and that its data is accessible from MATLAB. It is possible to reset the GPU device, so that a GPUArray or CUDAKernel object variable still exists in your MATLAB workspace even though it is no longer available on the GPU. For example, you can reset a GPU device using the command `gpuDevice(index)` or `reset(dev)`:

```
index = 1;
g = gpuDevice(index);
R = parallel.gpu.GPUArray.rand(4,4)
    0.5465    0.3000    0.4067    0.6110
    0.9024    0.8965    0.6635    0.7709
    0.8632    0.7481    0.9901    0.0420
    0.2307    0.7008    0.7516    0.5059

existsOnGPU(R)
     1

reset(g);  % Resets GPU device
existsOnGPU(R)
     0

R  % View GPUArray contents
Data no longer exists on the GPU.
```

Any attempt to use the data from `R` generates an error.

MATLAB Code on the GPU

GPU support is extended to include the following MATLAB code in functions called by `arrayfun` to run on the GPU:

```
and                        intmin                      power
beta                       ldivide                     rdivide
betaln                     le                          realmax
eq                         lt                          realmin
ge                         minus                       times
gt                         ne                          uint8
int8                       not                         uint16
int16                      or
intmax                     plus
```

Note the following enhancements and restrictions to some of these functions:

- `plus`, `minus`, `ldivide`, `rdivide`, `power`, `times`, and other arithmetic, comparison or logical operator functions were previously supported only when called with their operator symbol. Now they are supported in their functional form, so can be used as direct argument inputs to `arrayfun` and `bsxfun`.

- `arrayfun` and `bsxfun` on the GPU now support the integer data types `int8`, `uint8`, `int16`, and `uint16`.

The code in your function can now call any functions defined in your function file or on the search path. You are no longer restricted to calling only those supported functions listed in the table of Supported MATLAB Code.

Set CUDA Kernel Constant Memory

The new `setConstantMemory` method on the CUDAKernel object lets you set kernel constant memory from MATLAB. For more information, see the `setConstantMemory` reference page.

Latest NVIDIA CUDA Device Driver

This version of Parallel Computing Toolbox GPU functionality supports only the latest NVIDIA CUDA device driver.

Version History

Earlier versions of the toolbox supported earlier versions of CUDA device driver. Always make sure you have the latest CUDA device driver.

Enhanced Distributed Array Support

Newly Supported Functions

The following functions now support distributed arrays with all forms of codistributor (1-D and 2DBC), or are enhanced in their support for this release:

`isequaln`

Random Number Generation on Workers

MATLAB worker sessions now generate random number values using the combined multiplicative recursive generator (mrg32k3a) by default.

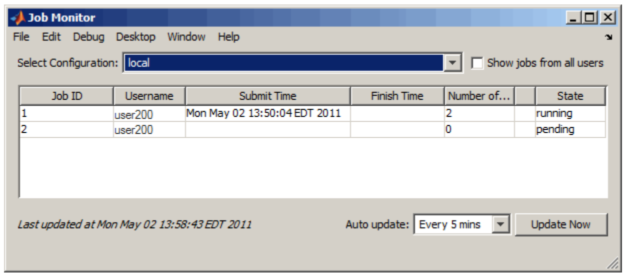
Version History

In past releases, MATLAB workers used the same default generator as a MATLAB client session. This is no longer the case.

R2011b

New Job Monitor

The Job Monitor is a tool that lets you track the jobs you have submitted to a cluster. It displays the jobs for the scheduler determined by your selection of a parallel configuration. Open the Job Monitor from the MATLAB desktop by selecting **Parallel** > **Job Monitor**.



Select Configuration: local

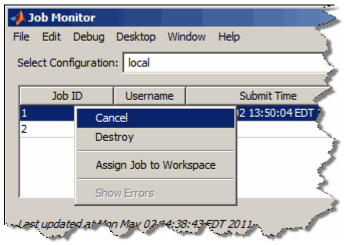
Show jobs from all users

Job ID	Username	Submit Time	Finish Time	Number of...	State
1	user200	Mon May 02 13:50:04 EDT 2011		2	running
2	user200			0	pending

Last updated at Mon May 02 13:58:43 EDT 2011

Auto update: Every 5 mins

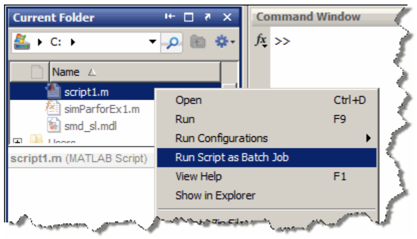
Right-click a job in the list to select a command from the context menu for that job:


Job Monitor
File Edit Debug Desktop Window Help
Select Configuration: local
Job ID
Username
Submit Time
1
2
02 13:50:04 EDT
Cancel
Destroy
Assign Job to Workspace
Show Errors
Last updated at Mon May 02 14:38:43 EDT 2011

For more information about the Job Monitor and its capabilities, see Job Monitor.

Run Scripts as Batch Jobs from the Current Folder Browser

From the Current Folder browser, you can run a MATLAB script as a batch job by browsing to the file's folder, right-clicking the file, and selecting **Run Script as Batch Job**. The batch job runs on the cluster identified by the current default parallel configuration. The following figure shows the menu option to run the script from the file `script1.m`:



Number of Local Workers Increased to Twelve

You can now run up to 12 local workers on your MATLAB client machine. If you do not specify the number of local workers in a command or configuration, the default number of local workers is determined by the value of the local scheduler's `ClusterSize` property, which by default equals the number of computational cores on the client machine.

Enhanced GPU Support

Latest NVIDIA CUDA Device Driver

This version of Parallel Computing Toolbox GPU functionality supports only the latest NVIDIA CUDA device driver.

Version History

Earlier versions of the toolbox supported earlier versions of CUDA device driver. Always make sure you have the latest CUDA device driver.

Deployment of GPU Applications

MATLAB Compiler generated standalone executables and components now support applications that use the GPU.

Random Number Generation

You can now directly create arrays of random numbers on the GPU using these new static methods for GPUArray objects:

```
parallel.gpu.GPUArray.rand
parallel.gpu.GPUArray.randi
parallel.gpu.GPUArray.randn
```

The following functions set the GPU random number generator seed and stream:

```
parallel.gpu.rng
parallel.gpu.RandStream
```

Also, `arrayfun` called with GPUArray data now supports `rand`, `randi`, and `randn`. For more information about using `arrayfun` to generate random matrices on the GPU, see Generating Random Numbers on the GPU.

GPUArray Support

The following functions now support GPUArray data:

```
chol                      isnan                     norm
diff                      lu                        not
eig                       max                       repmat
find                      min                       sort
isfinite                  mldivide                  svd
isinf
```

`mldivide` supports complex arrays. It also supports overdetermined matrices (with more rows than columns) when the second input argument is a column vector (has only one column).

`eig` supports only symmetric matrices.

`max` and `min` return only one output argument; they do not return an index vector.

The following functions are not methods of the GPUArray class, but they do work with GPUArray data:

angle	flipdim	mean
beta	fftshift	perms
betaln	ifftshift	squeeze
fliplr	kron	rot90
flipud		

The default display of GPUArray variables now shows the array contents. In previous releases, the display showed some of the object properties, but not the contents. For example, the new enhanced display looks like this:

```
M = gpuArray(magic(3))
M =
     8     1     6
     3     5     7
     4     9     2
```

To see that `M` is a GPUArray, use the `whos` or `class` function.

MATLAB Code on the GPU

GPU support is extended to include the following MATLAB code in functions called by `arrayfun` to run on the GPU:

```
rand
randi
randn
xor
```

Also, the handle passed to `arrayfun` can reference a simple function, a subfunction, a nested function, or an anonymous function. The function passed to `arrayfun` can call any number of its subfunctions. The only restriction is that when running on the GPU, nested and anonymous functions do not have access to variables in the parent function workspace. For more information on function structure and relationships, see Types of Functions.

Enhanced Distributed Array Support

Newly Supported Functions

The following functions are enhanced to support distributed arrays, supporting all forms of codistributor (1-D and 2DBC):

```
inv
meshgrid
ndgrid
sort
```

The following functions can now directly construct codistributed arrays:

```
codistributed.linspace(m, n, ..., codist)
codistributed.logspace(m, n, ..., codist)
```

Conversion of Error and Warning Message Identifiers

For R2011b, error and warning message identifiers have changed in Parallel Computing Toolbox.

Version History

If you have scripts or functions that use message identifiers that changed, you must update the code to use the new identifiers. Typically, message identifiers are used to turn off specific warning messages, or in code that uses a `try/catch` statement and performs an action based on a specific error identifier.

For example, the `'distcomp:old:ID'` identifier has changed to `'parallel:similar:ID'`. If your code checks for `'distcomp:old:ID'`, you must update it to check for `'parallel:similar:ID'` instead.

To determine the identifier for a warning, run the following command just after you see the warning:

```
[MSG,MSGID] = lastwarn;
```

This command saves the message identifier to the variable `MSGID`.

To determine the identifier for an error, run the following commands just after you see the error:

```
exception = MException.last;
MSGID = exception.identifier;
```

Tip Warning messages indicate a potential issue with your code. While you can turn off a warning, a suggested alternative is to change your code so that it runs warning-free.

Task Error Properties Updated

If there is an error during task execution, the task `Error` property now contains the non-empty `MException` object that is thrown. If there was no error during task execution, the `Error` property is empty.

The identifier and message properties of this object are now the same as the task's `ErrorIdentifier` and `ErrorMessage` properties, respectively. For more information about these properties, see the `Error`, `ErrorIdentifier`, and `ErrorMessage` reference pages.

Version History

In past releases, when there was no error, the `Error` property contained an MException object with empty data fields, generated by `MException('', '')`. Now to determine if a task is error-free, you can query the `Error` property itself to see if it is empty:

```
didTaskError = ~isempty(t.Error)
```

where `t` is the task object you are examining.

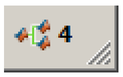
R2011a

Deployment of Local Workers

MATLAB Compiler generated standalone executables and libraries from parallel applications can now launch up to eight local workers without requiring MATLAB Distributed Computing Server software.

New Desktop Indicator for MATLAB Pool Status

When you first open a MATLAB pool from your desktop session, an indicator appears in the lower-right corner of the desktop to show that this desktop session is connected to an open pool. The number indicates how many workers are in the pool.



When you close the pool, the indicator remains displayed and shows a value of 0.

Enhanced GPU Support

Static Methods to Create GPUArray

The following new static methods directly create GPUArray objects:

```
parallel.gpu.GPUArray.linspace
parallel.gpu.GPUArray.logspace
```

GPUArray Support

The following functions are enhanced to support GPUArray data:

```
cat
colon
conv
conv2
cumsum
cumprod
eps
filter
filter2
horzcat
meshgrid
ndgrid
plot
subsasgn
subsindex
subsref
vertcat
```

and all the plotting related functions.

GPUArray Indexing

Because GPUArray now supports `subsasgn` and `subsref`, you can index into a GPUArray for assigning and reading individual elements.

For example, create a GPUArray and assign the value of an element:

```
n = 1000;
D = parallel.gpu.GPUArray.eye(n);
D(1,n) = pi
```

Create a GPUArray and read the value of an element back into the MATLAB workspace:

```
m = 500;
D = parallel.gpu.GPUArray.eye(m);
one = gather(D(m,m))
```

MATLAB Code on the GPU

GPU support is extended to include the following MATLAB code in functions called by `arrayfun` to run on the GPU:

```
&, |, ~, &&, ||,
while, if, else, elseif, for, return, break, continue, eps
```

You can now call `eps` with string inputs, so your MATLAB code running on the GPU can include `eps('single')` and `eps('double')`.

NVIDIA CUDA Driver 3.2 Support

This version of Parallel Computing Toolbox GPU functionality supports only NVIDIA CUDA device driver 3.2.

Version History

Earlier versions of the toolbox supported earlier versions of CUDA device driver. If you have an older driver, you must upgrade to CUDA device driver version 3.2.

Distributed Array Support

Newly Supported Functions

The following functions are enhanced to support distributed arrays, supporting all forms of codistributor (1-D and 2DBC):

```
arrayfun
cat
reshape
```

Enhanced mtimes Support

The `mtimes` function now supports distributed arrays that use a 2-D block-cyclic (2DBC) distribution scheme, and distributed arrays that use 1-D distribution with a distribution dimension greater than 2. Previously, `mtimes` supported only 1-D distribution with a distribution dimension of 1 or 2.

The `mtimes` function now returns a distributed array when only one of its inputs is distributed, similar to its behavior for two distributed inputs.

Version History

In previous releases, `mtimes` returned a replicated array when one input was distributed and the other input was replicated. Now it returns a distributed array.

Enhanced parfor Support

Nested for-Loops Inside parfor

You can now create nested `for`-loops inside a `parfor`-loop, and you can use both the `parfor`-loop and `for`-loop variables directly as indices for the sliced array inside the nested loop. See Nested Loops.

Enhanced Support for Microsoft Windows HPC Server

Support for 32-Bit Clients

The parallel computing products now support Microsoft Windows HPC Server on 32-bit Windows clients.

Search for Cluster Head Nodes Using Active Directory

The `findResource` function can search Active Directory to identify your cluster head node. For more information, see the `findResource` reference page.

Enhanced Admin Center Support

You can now start and stop mdce services on remote hosts from Admin Center. For more information, see Start mdce Service.

New Remote Cluster Access Object

New functionality is available that lets you mirror job data from a remote cluster to a local data location. This supports the generic scheduler interface when making remote submissions to a scheduler or when using a nonshared file system. For more information, see the `RemoteClusterAccess` object reference page.

R2010b

GPU Computing

This release provides the ability to perform calculations on a graphics processing unit (GPU). Features include the ability to:

- Use a GPU array interface with several MATLAB built-in functions so that they automatically execute with single- or double-precision on the GPU — functions including `mldivide`, `mtimes`, `fft`, etc.
- Create kernels from your MATLAB function files for execution on a GPU
- Create kernels from your CU and PTX files for execution on a GPU
- Transfer data to/from a GPU and represent it in MATLAB with GPUArray objects
- Identify and select which one of multiple GPUs to use for code execution

For more information on all of these capabilities and the requirements to use these features, see GPU Computing.

Job Manager Security and Secure Communications

You now have a choice of four security levels when using the job manager as your scheduler. These levels range from no security to user authentication requiring passwords to access jobs on the scheduler.

You also have a choice to use secure communications between the job manager and workers.

For more detailed descriptions of these features and information about setting up job manager security, see Set MJS Cluster Security.

The default setup uses no security, to match the behavior of past releases.

Generic Scheduler Interface Enhancements

Decode Functions Provided with Product

Generic scheduler interface decode functions for distributed and parallel jobs are now provided with the product. The two decode functions are named:

```
parallel.cluster.generic.distributedDecodeFcn
parallel.cluster.generic.parallelDecodeFcn
```

These functions are included on the workers' path. If your submit functions make use of the definitions in these decode functions, you do not have to provide your own decode functions. For example, to use the standard decode function for distributed jobs, in your submit function set `MDCE_DECODE_FUNCTION` to `'parallel.cluster.generic.distributedDecodeFcn'`. For information on using the generic scheduler interface with submit and decode functions, see Use the Generic Scheduler Interface.

Enhanced Example Scripts

This release provides new sets of example scripts for using the generic scheduler interface. As in previous releases, the currently supported scripts are provided in the folder

```
matlabroot/toolbox/distcomp/examples/integration
```

In this location there is a folder for each type of scheduler:

- `lsf` — Platform LSF®
- `pbs` — PBS
- `sge` — Sun™ Grid Engine
- `ssh` — generic UNIX-based scripts
- `winmpiexec` — mpiexec on Windows

For the updated scheduler folders (`lsf`, `pbs`, `sge`), subfolders within each specify scripts for different cluster configurations: `shared`, `nonshared`, `remoteSubmission`.

For more information on the scripts and their updates, see the `README` file provided in each folder, or see Supplied Submit and Decode Functions.

Version History

For those schedulers types with updated scripts in this release (`lsf`, `pbs`, `sge`), the old versions of the scripts are provided in the folder *`matlabroot`*`/toolbox/distcomp/examples/integration/old`. These old scripts might be removed in future releases.

batch Now Able to Run Functions

Batch jobs can now run functions as well as scripts. For more information, see the `batch` reference page.

batch and matlabpool Accept Scheduler Object

The `batch` function and the functional form of `matlabpool` now accept a scheduler object as their first input argument to specify which scheduler to use for allocation of compute resources. For more information, see the `batch` and `matlabpool` reference pages.

Enhanced Functions for Distributed Arrays

qr Supports Distributed Arrays

The `qr` function now supports distributed arrays. For restrictions on this functionality, type

```
help distributed/qr
```

mldivide Enhancements

The `mldivide` function (`\`) now supports rectangular distributed arrays. Formerly, only square matrices were supported as distributed arrays.

When operating on a square distributed array, if the second input argument (or right-hand side of the operator) is replicated, `mldivide` now returns a distributed array.

Version History

In previous releases, `mldivide` returned a replicated array when the second (or right-hand side) input was replicated. Now it returns a distributed array.

chol Supports 'lower' option

The `chol` function now supports the `'lower'` option when operating on distributed arrays. For information on using `chol` with distributed arrays, type

```
help distributed/chol
```

eig and svd Return Distributed Array

When returning only one output matrix, the `eig` and `svd` functions now return a distributed array when the input is distributed. This behavior is now consistent with outputs when requesting more than one matrix, which returned distributed arrays in previous releases.

Version History

In previous releases, `eig` and `svd` returned a replicated array when you requested a single output. Now they return a distributed array if the output is a single matrix. The behavior when requesting more than one output is not changed.

transpose and ctranspose Support 2dbc

In addition to their original support for 1-D distribution schemes, the functions`ctranspose` and `transpose` now support 2-D block-cyclic (`'2dbc'`) distributed arrays.

Inf and NaN Support Multiple Formats

Distributed and codistributed arrays now support `nan`, `NaN`, `inf` and `Inf` for not-a-number and infinity values with the following functions:

Infinity Value	Not-a-Number
`codistributed.Inf`	`codistributed.NaN`
`codistributed.inf`	`codistributed.nan`
`distributed.Inf`	`distributed.NaN`
`distributed.inf`	`distributed.nan`

Support for Microsoft Windows HPC Server 2008 R2

Parallel Computing Toolbox software now supports Microsoft Windows HPC Server 2008 R2. There is no change in interface compared to using HPC Server 2008. Configurations and other toolbox utilities use the same settings to support both HPC Server 2008 and HPC Server 2008 R2.

User Permissions for MDCEUSER on Microsoft Windows

The user identified by the `MDCEUSER` parameter in the `mdce_def` file is now granted all necessary privileges on a Windows system when you install the mdce process. For information about what permissions are granted and how to reset them, see Set the User.

Version History

In past releases, you were required to set the `MDCEUSER` permissions manually. Now this is done automatically when installing the mdce process.