

User's Guide to VelocityDB (Tuesday, September 14, 2021)

This guide compliments the [sample programs](#), [VelocityDB Quick Start](#), [VelocityGraph Quick Start](#) and the [API reference](#) provided on our site. Developers should review this in order to better understand how to build a VelocityDB-integrated application.

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Windows: Download and install a .NET development environment

If you don't already have, you need to download and install software that lets you edit, compile and debug .NET code. Some choices exist but for Windows development we recommend [Visual Studio](#) Community 2019(free) with all updates applied. The Professional or Enterprise versions can be even better, but they will cost you.

Mac (and partly Linux): Download and install a .NET development environment

If you don't already have, you need to download and install software that lets you edit, compile and debug .NET code. Some choices exist but for Mac development we recommend [Visual Studio](#).

Install a Git client, we like: <https://www.sourcetreeapp.com/>

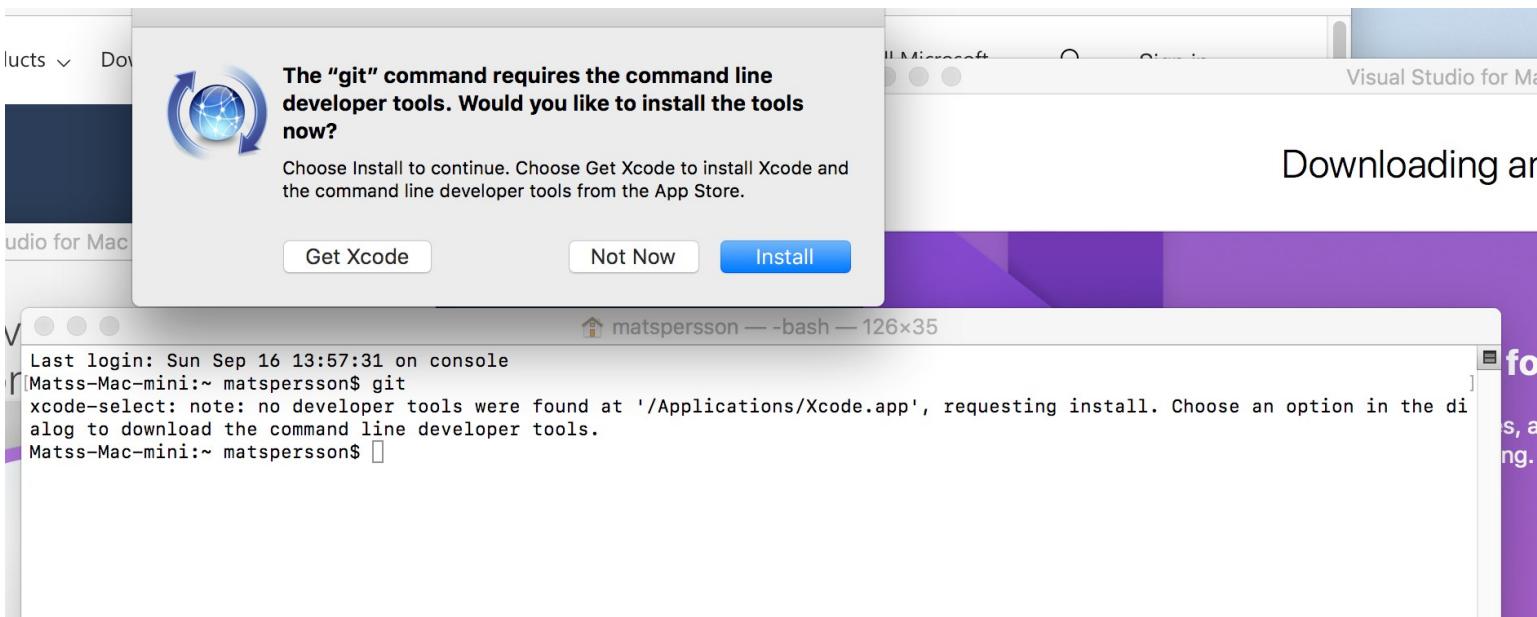
Go to [GitHub](#).

In a Terminal window do:

Go to directory where you want VelocityDB code, for instance:

```
Last login: Thu Sep 13 15:07:20 on ttys006  
Matss-Mac-mini:~ matspersson$ git clone https://github.com/VelocityDB/VelocityDB  
Cloning into 'VelocityDB'...  
remote: Counting objects: 15105, done.  
remote: Compressing objects: 100% (276/276), done.  
remote: Total 15105 (delta 418), reused 510 (delta 359), pack-reused 14462  
Receiving objects: 100% (15105/15105), 4.95 MiB | 8.59 MiB/s, done.  
Resolving deltas: 100% (13004/13004), done.  
Matss-Mac-mini:~ matspersson$
```

If git isn't already installed, you get



In such a case, choose to **Install** it, then try this again in a fresh terminal window.

Open the VelocityDB repository in Visual Studio

The screenshot shows the 'Visual Studio for Mac' interface. The top navigation bar includes 'Default > Default'. The main area has tabs for 'Get Started' and 'Recent'. The 'Recent' tab shows a list of recent projects, with 'VelocityDb.sln' highlighted. Below the recent projects, there's a message: 'Your recent solutions will appear here.'

At the bottom, a file browser dialog is open, showing a list of files and folders in the 'matspersson' directory. The 'VelocityDb.sln' file is selected and highlighted in blue. The dialog includes buttons for 'Options', 'Cancel', and 'Open'.

Name	Date Modified
Sample5	Today at 4:06 PM
SortedObjects	Today at 4:06 PM
SupplierTracking	Today at 4:06 PM
TextIndexer	Today at 4:06 PM
TriangleCounter	Today at 4:06 PM
UpdateClass	Today at 4:06 PM
UtilitiesModule	Today at 4:06 PM
VelocityDb.sln	Today at 4:06 PM
VelocityDBAccess	Today at 4:06 PM
VelocityDbBrowser	Today at 4:06 PM
VelocityDBExtensions	Today at 4:06 PM
VelocityDBExtensions2	Today at 4:06 PM
VelocityDBLINQPad	Today at 4:06 PM
VelocityDbSchema	Today at 4:06 PM
VelocityDbServer	Today at 4:06 PM
VelocityDBServerCore	Today at 4:06 PM
VelocityDbTests.nunit	Today at 4:06 PM
VelocityGraph	Today at 4:06 PM

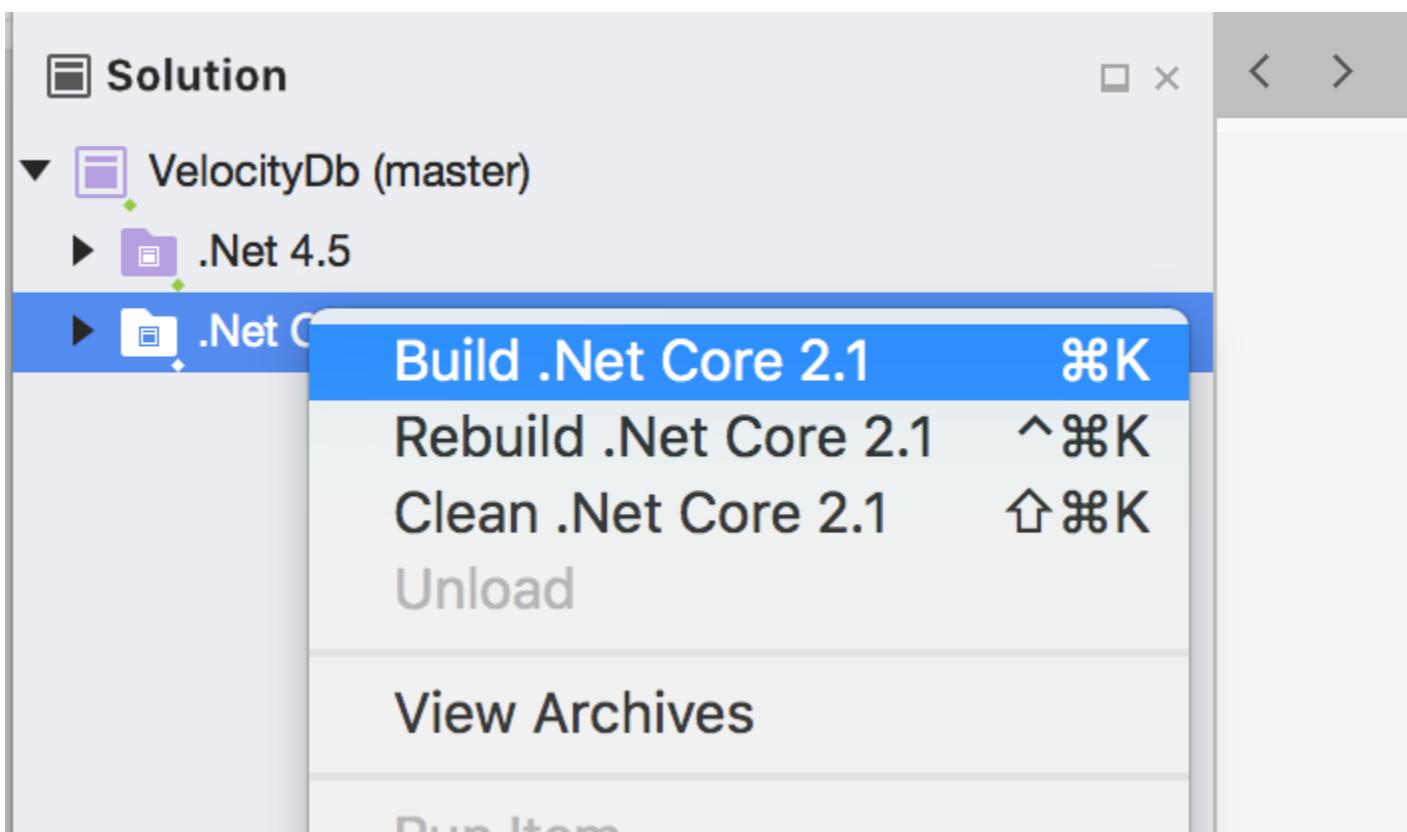


Visual Studio Community

[File](#)[Edit](#)[View](#)[Search](#)[Pro](#)

This solution is shared with Windows. For Mac you can only run the projects in the .Net Core 3.1 folder.

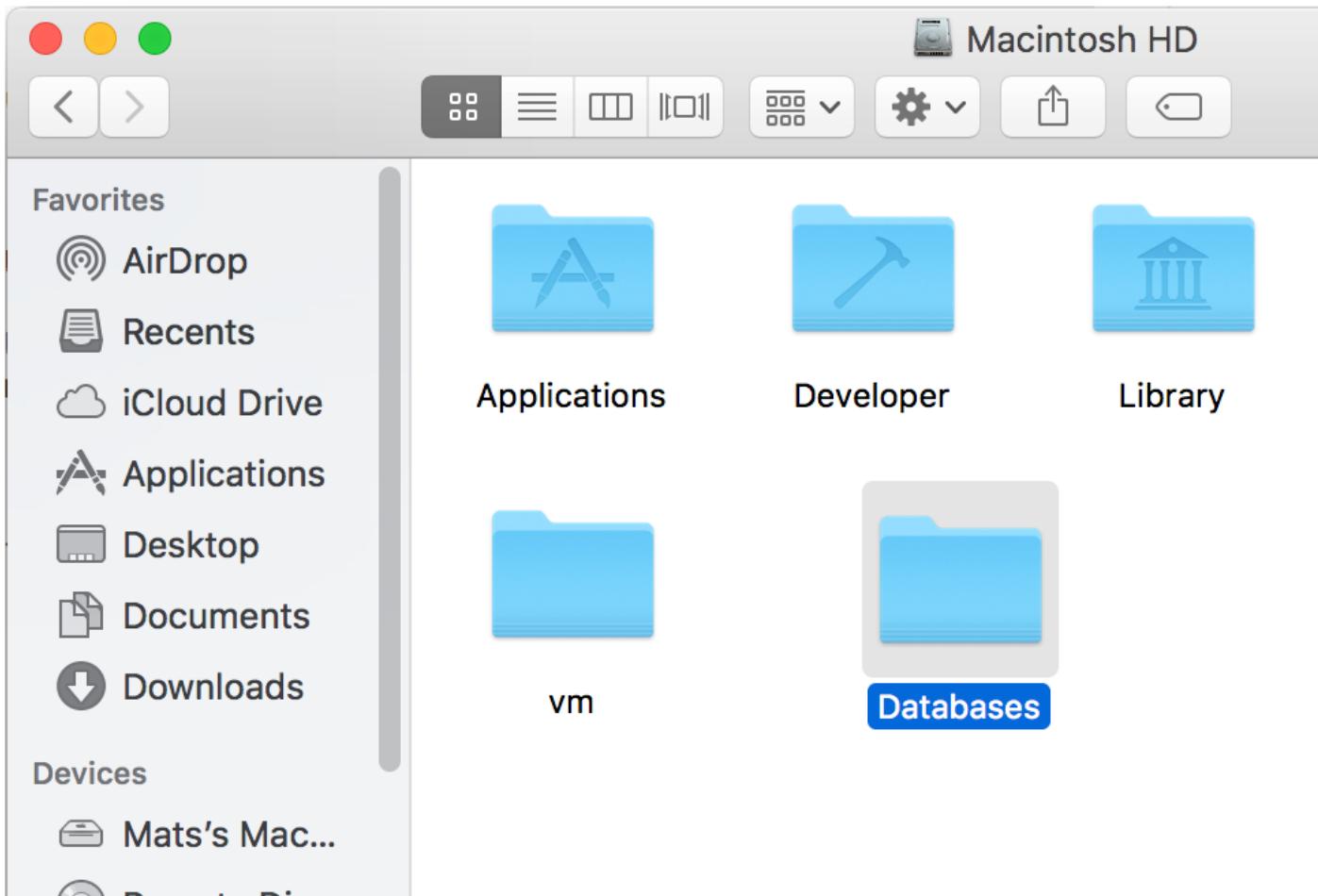
Select that folder and right click (*image needs to be updated to .NET Core 3.1*)



Build projects in this folder.

Currently, you will probably see one build error. We are still trying to figure out how to fix that one.

By default, databases will be stored in a sub folder to /Databases so create this folder before running any sample project.

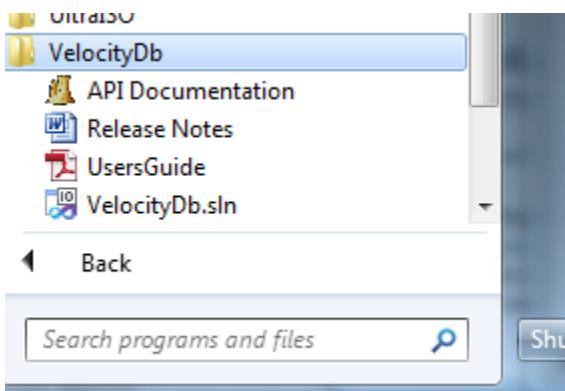


Some of these samples and Database Manager are WPF applications and these can currently not run with .NET Core. They will run with Windows and .NET Core 3 but not on a Mac.

Opening the samples solution, VelocityDB.sln

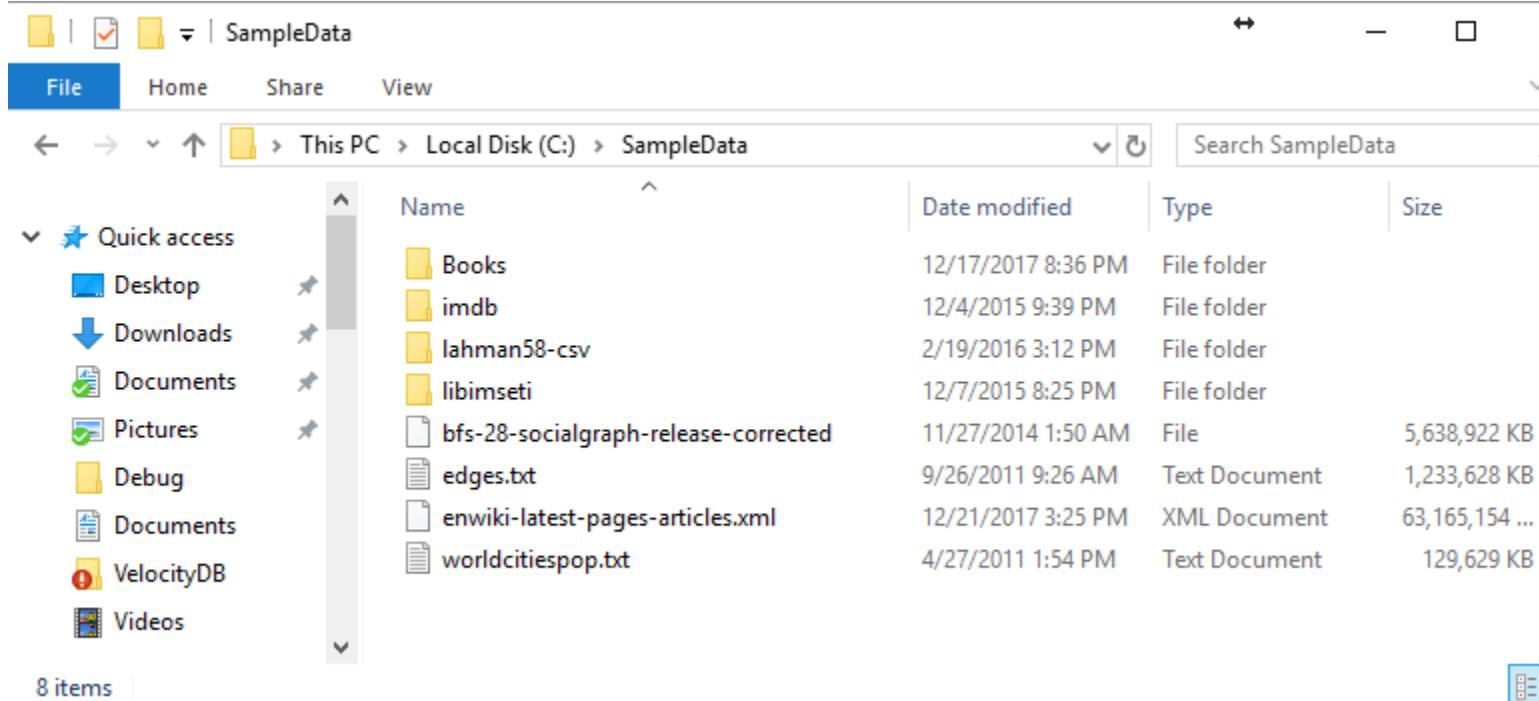
Open %USERPROFILE%\My Documents\VelocityDB\VelocityDB.sln

You can also start it by using the shortcut in the programs start menu.



SampleData

Many of the sample projects use data files. We expect these files to be in folder c:\SampleData



The screenshot shows a Windows File Explorer window. The address bar indicates the path: This PC > Local Disk (C:) > SampleData. The left sidebar shows 'Quick access' with links to Desktop, Downloads, Documents, Pictures, Debug, Documents, VelocityDB, and Videos. The main pane lists files and folders in the SampleData folder:

Name	Date modified	Type	Size
Books	12/17/2017 8:36 PM	File folder	
imdb	12/4/2015 9:39 PM	File folder	
lahman58-csv	2/19/2016 3:12 PM	File folder	
libimseti	12/7/2015 8:25 PM	File folder	
bfs-28-socialgraph-release-corrected	11/27/2014 1:50 AM	File	5,638,922 KB
edges.txt	9/26/2011 9:26 AM	Text Document	1,233,628 KB
enwiki-latest-pages-articles.xml	12/21/2017 3:25 PM	XML Document	63,165,154 ...
worldcitiespop.txt	4/27/2011 1:54 PM	Text Document	129,629 KB

8 items

Download a zip file with this SampleData folder [here](#).

If your C drive isn't the best location for these large files then create the sample folder on another drive and create a link from C:\SampleData to this location using the mklink command.

Open a Cmd window and type

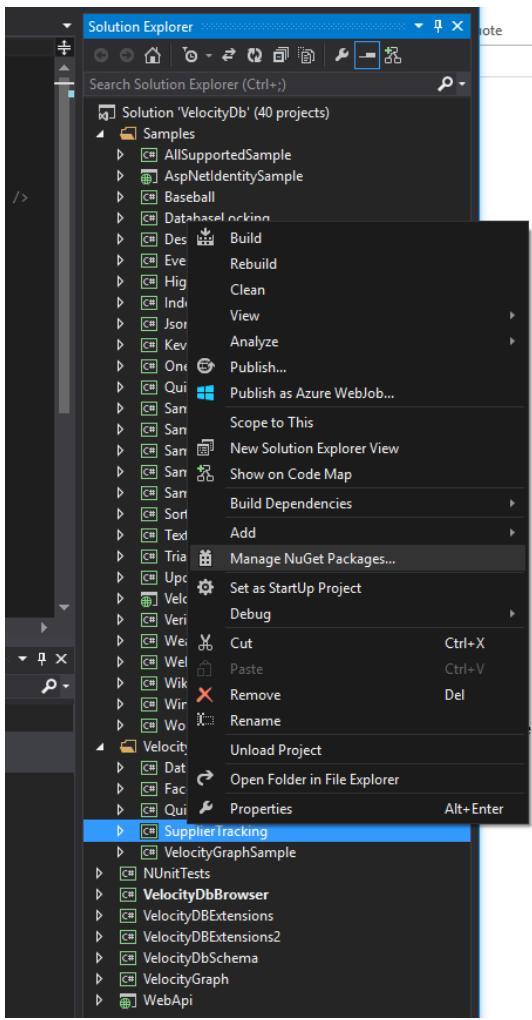
```
[C:]mklink /D SampleData F:\SampleData
```

Symbolic link created for SampleData <<=====> F:\SampleData

You may also want to do the same for C:\Databases

Using VelocityDB and VelocityGraph NuGets

This is the recommended way to add a reference to our DLLs. Right click on a project, like SupplierTracking, and select "Manage NuGet Packages..."



SupplierTracking - Manage NuGet Packages

Installed packages

Sort by: Name: Ascending

Search Installed packages (Ctrl+E)

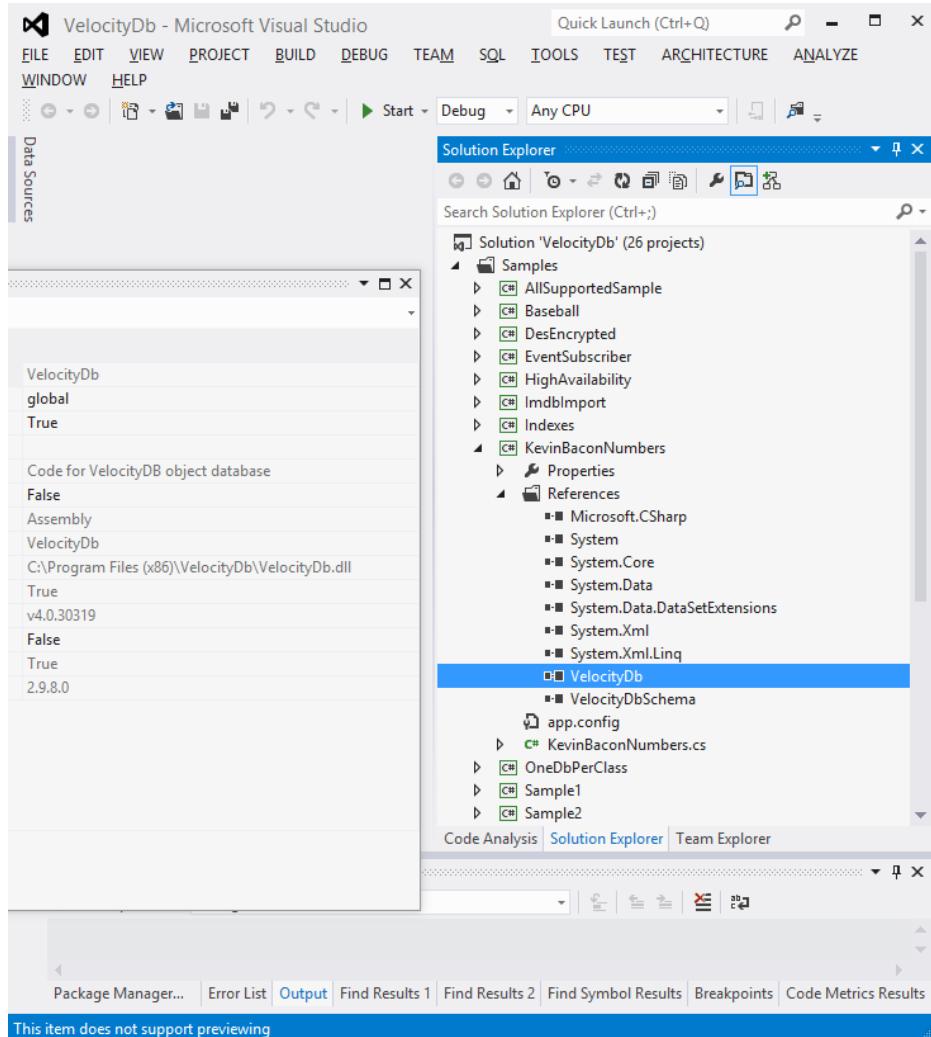
Icon	Name	Description	Action
	Castle.Core	Castle Project Core, including DynamicProxy, Logging Abstractions and DictionaryAdapter	Uninstall
	Frontenac.Blueprints	A .NET port of the Tinkerpop Stack. Blueprints provides a set of interfaces for the property graph data model.	
	Json.NET	Json.NET is a popular high-performance JSON framework for .NET	
	VelocityDB	VelocityDB is a NoSQL Object Database, a Graph Data Store and an excellent choice for Embedded/Distributed database.	
	VelocityGraph	VelocityGraph is a graph database for .NET. It is the first pure .NET graph database to fully implement the standard Bl...	

Each package is licensed to you by its owner. Microsoft is not responsible for, nor does it grant any licenses to, third-party packages.

Settings Close

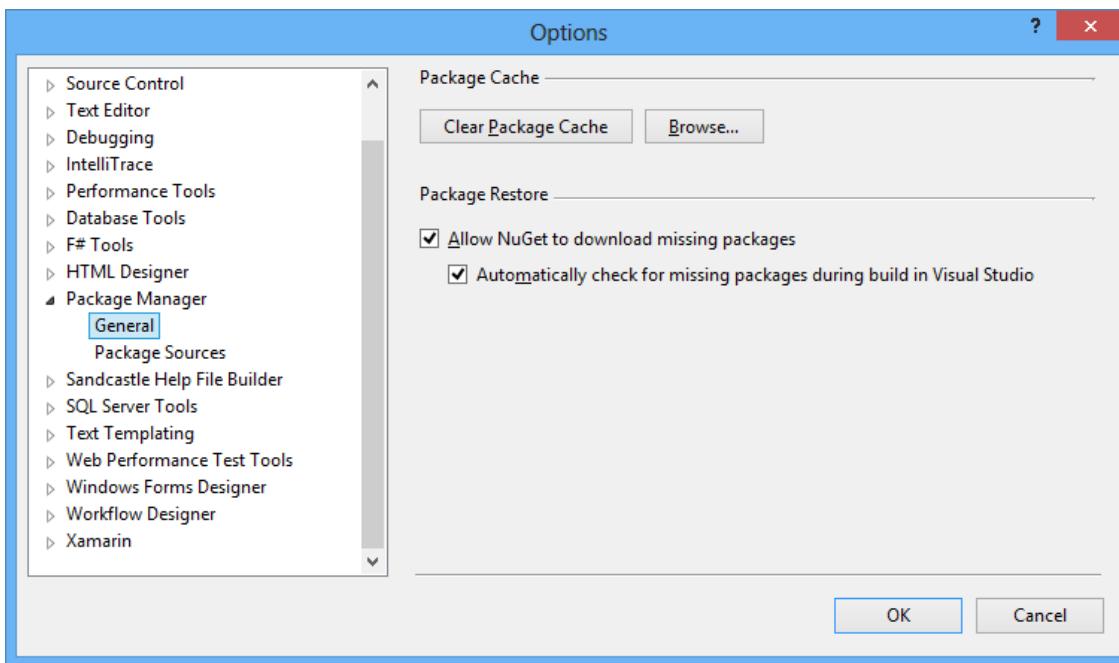
If not using our NuGets, manually add project reference to VelocityDB.dll

All sample projects should have a reference to VelocityDB.dll. The path used to VelocityDB.dll is C:\Program Files (x86)\VelocityDb\VelocityDB.dll, if your windows directory isn't C: or the reference is broken then you need to remove each project reference to VelocityDB.dll and add a new one using the path to it in your installation.



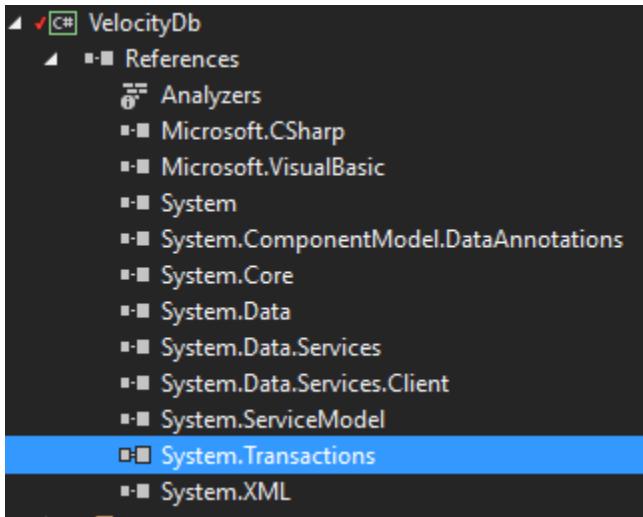
NuGet packages for solution

A few of the samples including VelocityGraph project uses 3rd party NuGet libraries. These libraries are not part of the installation but will be downloaded automatically when you attempt to build such a project. To make this happen you need to allow NuGet to download missing packages. If it still does not download (firewall blocking?) then you may need to manually install the missing NuGets.



Add reference to System.Transactions

VelocityDB now supports this type of distributed transactions. A transaction can now be shared between SQL Server and VelocityDB (and other resources/database systems). To make this work, any client using VelocityDB sessions must add a reference to [System.Transactions](#) (except for .NET.CORE and UniversalWindows which do not support System.Transactions).



Sample code using this type of distributed transaction is included in NUnit Tests. Here is part of it.

```
[Test]
public void GermanString()
{
    UInt64 id = 0;
    using (SessionNoServer session = new SessionNoServer(s_systemDir))
    {
        using (var trans = new TransactionScope())
        {
            session.BeginUpdate();
            VelocityDbSchema.Person person = new VelocityDbSchema.Person();
            person.LastName = "Med vänliga hälsningar";
        }
    }
}
```

```

        id = session.Persist(person);
        trans.Complete();
    }
}

```

GitHub

If you prefer not to use our installer and instead want to build our extensions, drivers, server and samples from the source code as in our [GitHub repository](#) then you need to manually first install

1. [Microsoft Sync Framework](#) (used by our extensions project VelocityDBExtensions2)
2. [LinqPad5](#) (used by our LinqPad driver)

Clone the repository: <https://github.com/VelocityDB/VelocityDB.git>

Selecting the correct VelocityDB Session Class

The most important class for users of VelocityDB is the *Session* class which contains the **Transaction Control API**, the **Persistence API**, the **Data Cache API** and more. VelocityDB provides three session types and does not limit usage. Your application can utilize all of them as necessary:

- `ServerClientSession` - Used for distributed databases or when clients are hosted remotely.

```

// initial DatabaseLocation directory and hostname
using (ServerClientSession session = new ServerClientSession("c:\\\\Databases", "DbServer"))
{
    session.BeginRead();
    // your code here
    session.Commit();
}

```

- `SessionNoServer` - Client and data are on the same host (unless it is a web application)

```

using (SessionNoServer session = new SessionNoServer("c:\\\\Databases"))
{
    session.BeginRead();
    // your code here
    session.Commit();
}

```

`SessionNoServerShared` - Client and data are on the same host (unless it is a web application) with use of pages and databases thread safe (other objects only partially) and by default VelocityDB adds some threading. One thread handles all index updates and another thread handles object encoding and page writes. You can optionally turn off the page write thread by a property setting in the session.

`session.WriteToDiskInSeparateDatabaseThreads = false`, the index update thread can also be disabled (but must be enabled if page write threads are) by setting `session.AddToIndexInSeparateThread = false;`

Having these worker threads active can dramatically improve update performance BUT at this time it may not due to the overhead of the Monitor locks. However, more could be parallelized, but it requires complicated object level thread locks. Eventually, we will probably merge in the worker thread functionality into `SessionNoServer` and eliminate `SessionNoServerShared`.

```

using (SessionNoServerShared session = new SessionNoServerShared ("c:\\\\Databases"))
{
    session.BeginRead();
    // your code here
    session.Commit();
}

```

The session class `ServerClientSession` is appropriate if the application will distribute data and/or clients across multiple hosts (where the clients are not just clients of a web site). Otherwise, `SessionNoServer` or `SessionNoServerShared` are appropriate. Of the two, the best choice is dependent upon the architecture of the application.

Additional benefits of using `ServerClientSession`

- ✓ Granularity of locking is page instead of database (file).
- ✓ Backup feature option
- ✓ Shared cache for all users (on server side)
- ✓ Deadlock detection (when pessimistic locking is used, with optimistic locking deadlocks don't happen)
- ✓ Change event subscription and notification

Benefits of using `SessionNoServer` or `SessionNoServerShared`

- ✓ No server installation required
- ✓ More stable, less can go wrong
- ✓ Can perform better with local files.

[Our video](#) talking about database concurrency control may help you decide what session to use.

Use `SessionNoServerShared` when the application must share a client-side cache between multiple threads. This may be the case for a web site that has limited RAM resources while also having a large amount of persistent data to manage.

It is recommended that a session is reused for multiple transactions since that will provide some caching benefits and also avoids some setup time, especially with `ServerClientSession`.

DO NOT pass objects between session instances. Once you read an object from a database, that object belongs to the session used to read it. Do not attempt to read an object using one session and the update it using another session. This will not work as expected and we may not detect it so it will fail silently.

Using database worker thread to speed up ingest/update of data

By default, starting in VelocityDB 4.6, each database will have a worker thread responsible for taking updated objects and writing these to disk. This is currently only available when using `SessionNoServerShared` session class. An application can turn this threading off by setting the session property

~~session.WriteToDiskInSeparateDatabaseThreads = false; For now, we recommend using SessionNoServer over SessionNoServerShared due a few remaining issues in SessionNoServerShared that may end up as exceptions being thrown.~~

Concurrent access to database data

`SessionNoServer` and `ServerClientSession` are not thread safe so don't use these with multi-threaded code. Be careful not to declare database access code `async` as it introduces possible multi-threading. `SessionNoServerShared` is thread safe but only at object, page and database access level. Complex objects such as `BTreeset` may still not be fully thread safe with update transactions. We recommend using a single `SessionNoServerShared` for all read only access and a `SessionPool` session for update transactions. See [Issues.aspx.cs](#) as an example of how to use it.

Optimistic locking versus Pessimistic locking

By default VelocityDB uses optimistic locking. Pessimistic locking can be turned on by a session constructor parameter. With optimistic locking, reads are always possible except for uncommitted new databases and multiple updaters are

allowed but only the first writer will succeed, the other writers of the same page ([ServerClientSession](#)) or database ([SessionNoServer](#)) will get an optimistic locking exception. Once you decide using optimistic/pessimistic concurrency control, stick with your choice. **Do not mix** sessions using optimistic concurrency control with sessions using pessimistic concurrency control. If your application often try to update the same database/page concurrently, you are better off using **pessimistic** locking as it will wait for a lock to be released and then proceed to do the updates successfully in each concurrent transaction unless a [deadlock](#) is detected.

SessionPool class

Use this class when you have frequent database requests coming in from multiple clients possibly simultaneously, i.e. a web application serving multiple clients. With [SessionPool](#), you will reuse a set of sessions. With reuse comes a cache of databases, pages and objects. Having the cached data makes access to data faster compared to starting with a brand new fresh session each time. Keep the number of sessions allocated for the pool small to reduce memory usage, we think 3 sessions should be enough in most cases. If more than the set maximum sessions are requested from [SessionPool](#) then a temporary new session will created and then disposed after usage so that memory usage is reduced. It is important that your code frees the session back into the pool after each usage.

```
const int numberOfSessions = 5;
SessionPool pool = new SessionPool(numberOfSessions, () => new SessionNoServer(systemDir));
int sessionId = -1;
SessionBase session = null;
try
{
    session = pool.GetSession(out sessionId);
    session.BeginUpdate();
    for (int i = 0; i < 1000; i++)
    {
        Man man = new Man();
        session.Persist(man);
    }
    session.Commit();
}
catch (Exception e)
{
    if (session != null)
        session.Abort();
    Console.WriteLine(e.Message);
    throw e;
}
finally
{
    pool.FreeSession(sessionId, session);
}
```

Composite Object Identifier

All normal VelocityDB persistent objects have an associated composite object identifier. It is encoded as a [UInt64](#) with three composite parts; a database number (upper 32 bits), a page number and a slot number. The **Id** property returns an objects encoded object identifier and the **Oid** property returns the decoded object identifier as the struct **Oid**. A reference to a persistent object is persistently stored as an object identifier, it is normally a [UInt64](#) but it can also be using a short object identifier, a [UInt32](#), when the reference is to another object within the same database. The decoded short reference as a struct is [OidShort](#). Use the special [OidShort](#) collection classes and tag object references with the attribute [\[UseOidShort\]](#) as in:

```
[Serializable]
[UseOidShort]
```

```
internal class Recovery : OptimizedPersistable
```

and for a specific member:

```
[UseOidShort]  
public VelocityDbListOidShort<FreeSpace> theArray;
```

DatabaseLocation

This is a directory on some host. The initial `DatabaseLocation` is created when you create your first persistent object. You specify the directory when you create the session class. You can create additional database locations like:

```
using (ServerClientSession session = new ServerClientSession(systemDir, Dns.GetHostName()))  
{  
    session.BeginUpdate();  
    DatabaseLocation otherLocation = new DatabaseLocation(Dns.GetHostName(), location2Dir,  
locationStartDbNum, locationEndDbNum, session, true, 0);  
    otherLocation = session.NewLocation(otherLocation);  
    session.Commit();  
}
```

You need to commit the initial `DatabaseLocation` before other sessions (clients) can access it.

Moving/Copying Databases in a DatabaseLocation to a different Host/Directory

If you only have a single directory for your set of connected databases, you may wonder why we need to update anything. The reason is that some usage scenarios may use one hundred or more database locations in a single set of databases. That is why we maintain a catalog of database locations in 2.odb.

First move your database files to desired host and directory, then do like:

```
using (var session = new SessionNoServer("CompanyBootLocation"))  
{ // NO longer required starting in version 10.1, we do this automatically when we detect a new default/bootup  
location in an update transaction  
    session.RelocateDefaultDatabaseLocation(); // update default database location without first starting  
a transaction  
}  
  
// other locations you will have to update yourself  
using (var session = new SessionNoServer("CompanyBootLocation"))  
{  
    session.BeginUpdate();  
    session.RelocateDatabaseLocationFor(session.DatabaseNumberOf(typeof(InsuranceCompany)),  
SessionBase.LocalHost, "InsuranceCompanies");  
    session.Commit();  
}
```

Page Compression

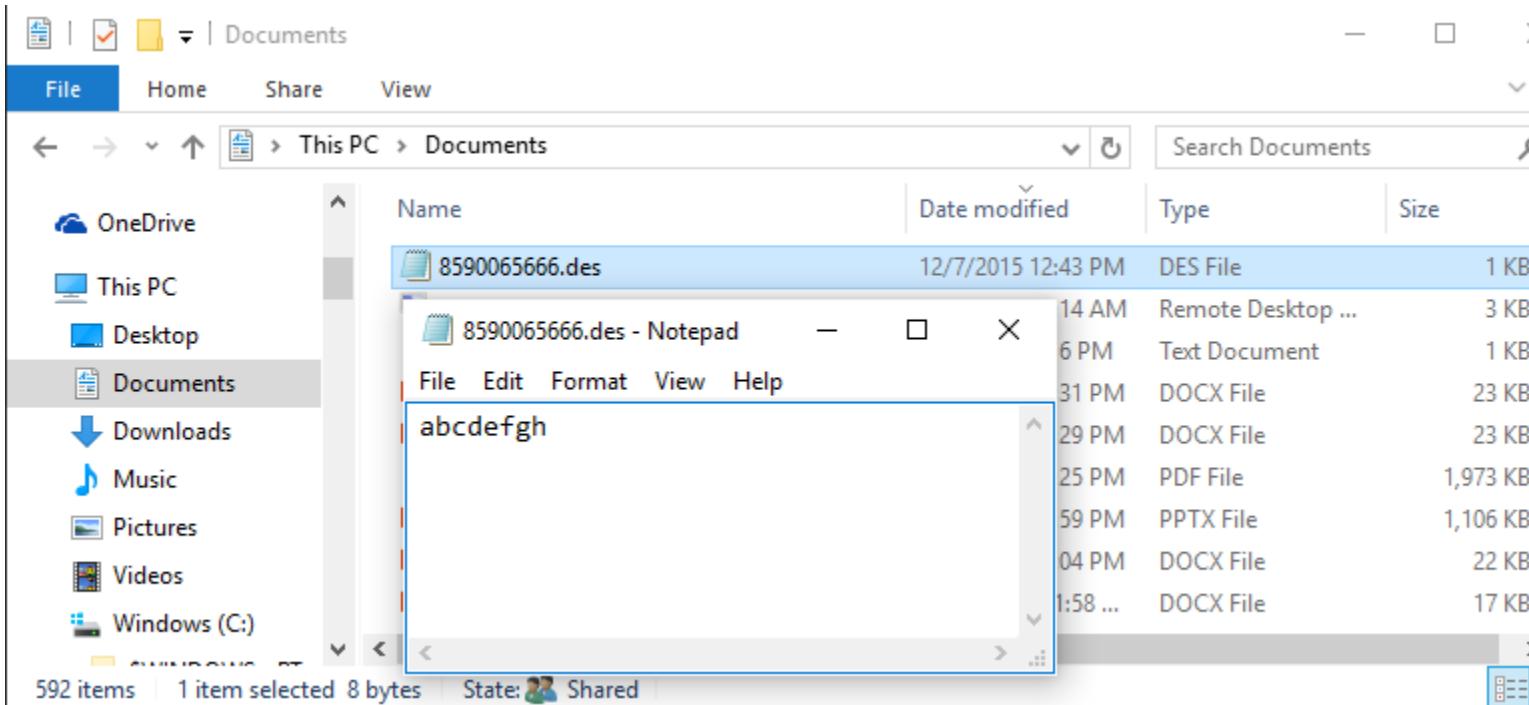
Page compression is now by default turned off. You can turn it on by setting the constructor parameter when you create a `DatabaseLocation`.

The initial/default `DatabaseLocation` is created when you run your first update transaction with a specified directory that does not already contain databases 0, 1, and 2 (0.odb, 1.odb, and 2.odb).

If you want page compression turned on for this `DatabaseLocation`, set `SessionBase.DefaultCompressPages` to true first. This static variable is also used when you create your own `DatabaseLocation` and not specifying the `compressPages` constructor parameter.

Encrypt Page data

By default page data is not encrypted. You can enable Des encryption when you create a [DatabaseLocation](#). Our sample application [DesEncrypted](#) shows how to do it. You can also use [DatabaseManager](#) to make it happen. Des encryption requires an 8 character (8 bytes) key. Once you start using Des encryption, this key is stored in a file within the active Users Documents folder. Filename is based on Id of the [DatabaseLocation](#).



This file needs to be copied to all Users Documents folder for access to such encrypted pages. **DO NOT** change the key after you have persisted pages with Des encryption.

We can provide other encryption mechanisms on request and we can also rework API such that custom encryption methods can be used.

Databases

A database corresponds to a file within a [DatabaseLocation](#). The file name of a [Database](#) is <database number>.odb. When you create your first persistent data, three system databases are created:

- **0.odb**
Contains a log of update transactions and the recovery mechanism data.
- **1.odb**
Contains the schema objects
- **2.odb**
Contains the [DatabaseLocation](#) objects.

These system databases must be committed by a session before other sessions can use them. This is true for any new database; a database must be committed before other sessions can access it.

A new uncommitted [Database](#) is named <database number>.new and an uncommitted deleted [Database](#) is named <database number>.del.

A [Database](#) can be created explicitly using session API or implicitly by placing a new persistent object with database part of the object identifier corresponding to an unallocated database number.

Compacting Databases

Database pages uses versioning so that a page can be updated in one transaction and prior committed state of that page can be read by other transactions. After updating pages there may be available space within a Database file. This is because when a Database page is updated, it is not written back to the same location in the file, a new version of the page is created somewhere else in the file. A new version of a page may be smaller/larger than the prior version. Space for a new page version is allocated from a best fit free area. If no free area large enough is available, then the database file is extended and the page is allocated at the end of the file. This versioning can create up to two versions of each page in a database. By calling `SessionBase.Compact()` this extra database space is reclaimed and pages are physically ordered in page number order. This may improve performance. `ServerClientSession` currently does not implement `Compact()` so for now use `SessionNoServer` when calling `Compact()`. Call `Compact()` outside the scope of any transaction.

Notice! Backup your database files before attempting a `Compact()` as it is a potentially very large update to your database structures. Avoid attempting to make other updates to the databases while running `Compact()`.

VelocityDB license database

Download your VelocityDB license database file from <http://www.velocitydb.com/Secure/License.aspx>

The license database file is named **4.odb**. Copy this file to all database directories used for the system databases 1.odb ... 9.odb. This is the directory you specify when creating the session instance. Some of the sample applications provided with the download will fail without a license database. If a license database is missing when a license check is happening, VelocityDB will copy a license database from your “Downloads” directory if such a file exists and use it for the license check. A license check does not require an active internet connection. VelocityDB never tries to talk to any other host as part of the license check.

Replication

Databases in the initial `DatabaseLocation` that starts with database id 0 can be replicated to multiple directories on multiple hosts. This enables high availability, if one replica isn't available then another available one is used if available. Under normal operation, all changes are applied to all replicas. If a replica is found to be out of sync, it is refreshed from one of the replicas that is up to date. Using replication is optional and is activated by using a special version of the `ServerClientSession` constructor as in:

```
alternateSystemBoot = new List<ReplicaInfo> { new ReplicaInfo { Path = "Replica1" }, new ReplicaInfo { Path = "Replica2" }, new ReplicaInfo { Path = "Replica3", Host = s_systemHost2 } };
using (var session = new ServerClientSession(alternateSystemBoot))
```

Replicas can be added/removed by changing the `List<ReplicaInfo>` constructor parameter.

As of February 2019, this is a new feature with some limitations, we will incrementally update the replication code with automatic fault tolerance until it's perfected, handling all cases and is rock solid. Please help us with ideas and test cases for how to get there.

Storing Databases in the Cloud

Microsoft Azure

It is very easy to store databases in the cloud with replication, backup and safe access using Microsoft Azure File storage. Microsoft provide free trials of Azure. To store databases on Azure servers, all you need to do is to use a file share.

See description [here](#).

Once you have mounted your Azure directory as a local drive such as z:, you can start using it for reading and updating Azure hosted storage. We also started work on an AzureSession class based on SessionNoServer as a direct way to access Azure hosted databases. The code for this is in our download as part of VelocityDbExtensions project file name AzureSession.cs. It currently isn't fully working due to challenges with Azure Stream that only can be read only or update only, required explicit Flush() and file resizing. In any case the shared drive solution is more transparent and have less restriction so use it for now.

Example: `net use z: \\samples.file.core.windows.net\logs /u:samples<storage-account-key>`

ServiceFabric Remoting

Microsoft now supports a micro service technology they named "[ServiceFabric](#)". It is a very cool option that lets you deploy services on your local computer, an own server or in the cloud using Microsoft Azure. It lets you communicate in many ways between client and server but the coolest/easiest way is by using [ServiceFabric Remoting](#). All you do is define and interface and then you implement the interface in the service fabric service. Clients just instantiate the interface by a proxy (one line statement) and then the service becomes available as if it was API within the client process. Very nice! On the server (service) side you do not need to use the VelocityDBServer, you can use the embedded client sessions instead (SessionNoServer and/or SessionNoServerShared).

Accessing remote databases without using VelocityDBServer

If remote server is within a Windows network, [UNC path](#) to databases can be used. Easiest way to do it is by setting SessionBase.BaseDatabasePath, i.e.

```
static readonly string s_systemDir = "UncPath"; // appended to SessionBase.BaseDatabasePath
static int Main(string[] args)
{
    SessionBase.BaseDatabasePath = @"\\FindPriceBuy\BenchmarkDatabases";
    for (int i = 0; i < 5; i++)
        using (var session = new SessionNoServer(s_systemDir))
    {
        Console.WriteLine($"Running with databases in directory: {session.SystemDirectory}");
    }
}
```

Pages

A VelocityDB page can contains one or more persistent objects. The size of a [Page](#) can vary dynamically. A page is stored within a Database file. Each [Page](#) has a [PageInfo](#) header that contains information about a page. A Page can optionally be encrypted and/or compressed.

Transactions

All interaction with databases and persistent object require an active transaction. With VelocityDB we provide two kinds of transactions; update and read only. With an update transaction, you are permitted to update and add persistent data. With a read only transaction, an exception will be thrown by VelocityDB if you try to update persistent data. Only one concurrent transaction per session is permitted. A transaction is started and committed by API on the session classes. An application may examine in memory persistent object without being in a transaction but an exception will be thrown if any persistent operation is requested like reading a page from a database.

```
public virtual void BeginRead(bool doRecoveryCheck = true)
public virtual void BeginUpdate()
public virtual void Commit(bool doRecoveryCheck = true)
public virtual void Abort()
```

Try Catch blocks around all transactions

It is particularly important to add this around update transactions. If you don't add it around an update transaction then you could end up corrupting your data. You should always abort the active transaction if you get an exception.

```
static int Main(string[] args)
{
    using (SessionNoServer session = new SessionNoServer(systemDir))
    {
        Console.WriteLine("Running with databases in directory: " + session.SystemDirectory);
        try
        {
            session.BeginUpdate();
            Company company = new Company();
            company.Name = "MyCompany";
            session.Persist(company);
            Employee employee1 = new Employee();
            employee1.Employer = company;
            employee1.FirstName = "John";
            employee1.LastName = "Walter";
            session.Persist(employee1);
            session.Commit();
        }
        catch (Exception ex)
        {
            Trace.WriteLine(ex.Message);
            session.Abort();
        }
    }
    Retrieve();
    return 0;
}
```

Why we need transaction for reads

With optimistic locking option (the default) there is no locking reason for a transaction when only reading objects. If the other locking model is used, pessimistic locking, then read only transactions are needed because they define the scope of read locks. A session constructor parameter is used for requesting optimistic or pessimistic locking model. Another reason we need read only transaction is cache management and validation. Each Database, Page and Object is cached within a session instance. Each cached Database is validated in the beginning of a transaction, making sure cached version is up to date. If reads are frequent among multiple threads, it may make sense to use a shared session for the reads, [SessionNoServerShared](#), and maintain an infinitely long open optimistic locking read transaction. Call [ForceDatabaseCacheValidation\(\)](#) frequently when there is possible other active database clients so that your cache stays up to date. Alternatively trigger validation of only selected databases by setting the Database property [CachedVerified](#) to [false](#).

Enabling recovery check for read transactions

By default when a BeginRead() transaction is started, we do not check for the very unlikely event that our previous update transaction was not completely persisted so that we need to revert to prior state. By skipping this check in read transactions we save time. To enable the check start transaction with BeginRead(true) instead.

Event subscription and notification

With use of ServerClientSession you can subscribe to object add/modification events. The [EventSubscriber](#) sample, part of your VelocityDb.sln, in our download shows how it can be used.

A session can subscribe to changes made in other ServerClientSession sessions in any process on any host.

An event subscription is started like

```
session.SubscribeToChanges(typeof(Person));
```

subscribes to any updates involving Person objects.

```
session.SubscribeToChanges(typeof(Woman), "OlderThan50");
```

subscribes to any updates involving Woman objects where property OlderThan50 evaluates to true.

Events are received at the start of a transaction by using special begin transaction API

```
List<Oid> changes = session.BeginReadWithEvents();
```

or

```
List<Oid> changes = session.BeginUpdateWithEvents();
```

How to enable persistent objects of some class

There are three major choices for enabling persistence.

1. Make your data model class a subclass of [OptimizedPersistable](#)
2. Implement the interface [IOptimizedPersistable](#). See the sample class [PersistenceByInterfaceSnake](#) as a template for how to implement the required interface API.
3. Implement the interface [ISerializable](#)

These three ways of enabling persistence can be mixed, some classes may implement the interface and others may be subclasses of [OptimizedPersistable](#).

Objects of [ValueType](#) and arrays are embedded within a parent persistent object.

In addition, almost any type of object, except Delegate and Pointer instances, can be made persistent but this way is not very efficient due to requiring use of a fairly inefficient [ConditionalWeakTable](#) internally by VelocityDB due to such objects not maintaining an object identifier as a field.

[OptimizedPersistable](#) implements [IOptimizedPersistable](#).

Implementing ISerializable

This way is NOT recommended as it slows down serialization and deserialization. This is also true for [ISerializable](#) classes that you may use from some library. Be prepared, it will be slow. HashSet is about 60x slower to deserialize vs List/[BTreeSet](#) due to it being ISerializable.

In some cases regular serialization/deserialization is not desired. Good examples of that are the date classes in [NodaTime](#). These object de-serialize to use a shared [CalendarSystem](#) instance. (Very clever!)

If your class implements both ISerializable and IDeserializationCallback then VelocityDB will call your callback function OnDeserialization.

Sample simple use of ISerializable (part of NUnit tests included with our product download & on GitHub)

```
public class TestISerializable : ISerializable
{
    public int m_intOne;
    public string m_stringOne;
    public string m_notSerialized;
```

```

public TestISerializable()
{
    m_stringOne = "one";
    m_intOne = 1;
    m_notSerialized = "not";
}

private TestISerializable(SerializationInfo info, StreamingContext context)
{
    m_intOne = info.GetInt32("m_intOne");
    m_stringOne = info.GetString("m_stringOne");
    m_notSerialized = "transient";
}

void ISerializable.GetObjectData(SerializationInfo info, StreamingContext context)
{
    info.AddValue("m_intOne", m_intOne);
    info.AddValue("m_stringOne", m_stringOne);
}
}

```

Collections using OptimizedPersistable.Equals and GetHashCode

Note that `OptimizedPersistable` overrides Equals and GetHashCode

```

public override bool Equals(Object obj)
{
    OptimizedPersistable otherPersistentObject = obj as OptimizedPersistable;
    if (otherPersistentObject != null)
    {
        if (otherPersistentObject.IsPersistent && IsPersistent)
            return m_id.Equals(otherPersistentObject.m_id);
        return base.Equals(obj);
    }
    else
        return false;
}

public override int GetHashCode()
{
    if (m_id == 0)
        return base.GetHashCode();
    return (int)Oid.DatabaseNumber(Id) << 24 + (int)Id;
}

```

As you can see the behavior is different when object becomes persistent. If you use these functions for objects that you want to use persistently then it is **VERY** important that such objects are persisted **BEFORE** being used with Equals and/or GetHashCode or else you will end up with a corrupt HashSet or whatever way you triggered use of these methods.

DateTime

It is good practice to persist all `DateTime` structures using Coordinated Universal Time (UTC) `DateTimeKind`. If you store `DateTime` using `DateTimeKind.Local`, it is your responsibility to also store/track `TimezoneInfo`, it is not stored with `DateTime`.

Database Schema

VelocityDB maintains a special database, 1.odb, for all database schema. Objects in this database of type `VelocityDbType`, `TypeVersion` and `DataMember` describes the types and fields your application persists. It is **important** that once you persist an instance of a class that this class remains within your application anytime you access your

databases. Otherwise, database schema will not be able to resolve schema class with a .NET type. If you accidentally do this, it is possible to delete such an entry after you make sure there isn't any instances of it stored in any database. Contact us for assistance if this is required. You can also add an empty (stub) class of the missing type so that it resolves to something at schema load time.

Register all types that you plan on persisting

It is not mandatory, but by doing so you ensure that schema is created one way no matter in what order you persist objects and you avoid potential lock conflicts with the schema database (1.odb). For VelocityGraph, we do this the first time a Graph is persisted as:

```
public override UInt64 Persist(Placement place, SessionBase session, bool persistRefs = true,
                               bool disableFlush = false, Queue<IOptimizedPersistable> toPersist = null)
{
    if (IsPersistent)
        return Id;
    session.RegisterClass(typeof(Graph));
    session.RegisterClass(typeof(BTreeMap<EdgeType, EdgeType>));
    session.RegisterClass(typeof(PropertyType));
    session.RegisterClass(typeof(VertexType));
    session.RegisterClass(typeof(VelocityDbList<VertexType>));
    session.RegisterClass(typeof(EdgeType));
    session.RegisterClass(typeof(UnrestrictedEdge));
    session.RegisterClass(typeof(VelocityDbList<Range<ElementId>>));
    session.RegisterClass(typeof(VelocityDbList<EdgeType>));
    session.RegisterClass(typeof(Range<VertexId>));
    session.RegisterClass(typeof(BTreeSet<Range<VertexId>>));
    session.RegisterClass(typeof(BTreeSet<EdgeType>));
    session.RegisterClass(typeof(BTreeSet<EdgeIdVertexId>));
    session.RegisterClass(typeof(BTreeMap<EdgeId, ulong>));
    session.RegisterClass(typeof(BTreeMap<EdgeId, UnrestrictedEdge>));
    session.RegisterClass(typeof(BTreeMap<string, PropertyType>));
    session.RegisterClass(typeof(BTreeMap<string, EdgeType>));
    session.RegisterClass(typeof(BTreeMap<string, VertexType>));
    session.RegisterClass(typeof(BTreeMap<VertexId, BTreeSet<EdgeIdVertexId>>));
    session.RegisterClass(typeof(BTreeMap<VertexType, BTreeMap<VertexId, BTreeSet<EdgeIdVertexId>>>));
    session.RegisterClass(typeof(BTreeMap<EdgeType, BTreeMap<VertexType, BTreeMap<VertexId, BTreeSet<EdgeIdVertexId>>>>));
    session.RegisterClass(typeof(BTreeMap<string, BTreeSet<ElementId>>));
    session.RegisterClass(typeof(BTreeMap<int, BTreeSet<ElementId>>));
    session.RegisterClass(typeof(BTreeMap<Int64, BTreeSet<ElementId>>));
    session.RegisterClass(typeof(PropertyTypeT<bool>));
    session.RegisterClass(typeof(PropertyTypeT<int>));
    session.RegisterClass(typeof(PropertyTypeT<long>));
    session.RegisterClass(typeof(PropertyTypeT<double>));
    session.RegisterClass(typeof(PropertyTypeT<DateTime>));
    session.RegisterClass(typeof(PropertyTypeT<string>));
    session.RegisterClass(typeof(PropertyTypeT<IComparable>));
    session.RegisterClass(typeof(AutoPlacement));
    return base.Persist(place, session, persistRefs, disableFlush, toPersist);
}
```

If your application schema is using [indexes](#)

The following is from the test aaa_IndexRegisterClass in project NUnitTests and class is IndexingTest

```
public class InsuranceCompany : OptimizedPersistable
{
    [Index]
    [UniqueConstraint]
    [OnePerDatabase]
    string name;
    string phoneNumber;

    public InsuranceCompany(string name, string phoneNumber)
```

```

    {
        this.name = name;
        this.phoneNumber = phoneNumber;
    }

    [FieldAccessor("name")]
    public string Name
    {
        get
        {
            return name;
        }
    }
}

[UniqueConstraint]
[Index("_registrationState,_registrationPlate")]
public class Car : Vehicle
{
    string _registrationState;
    string _registrationPlate;
    [Index]
    InsuranceCompany _insuranceCompany;
    string _insurancePolicy;

    public Car(string color, int maxPassengers, int fuelCapacity, double litresPer100Kilometers, DateTime modelYear,
              string brandName, string modelName, int maxSpeed, int odometer, string registrationState, string registrationPlate,
              InsuranceCompany insuranceCompany, string insurancePolicy):base(modelYear,color, maxPassengers, fuelCapacity, litresPer100Kilometers,
brandName, modelName, maxSpeed, odometer)
    {
        _registrationState = registrationState;
        _registrationPlate = registrationPlate;
        _insuranceCompany = insuranceCompany;
        _insurancePolicy = insurancePolicy;
    }
    [FieldAccessor("_registrationState")]
    public string RegistrationState => _registrationState;
    [FieldAccessor("_registrationPlate")]
    public string RegistrationPlate => _registrationPlate;
}

```

You should register a few additional index related classes:

```

session.RegisterType(typeof(IndexDescriptor));
session.RegisterType(typeof(BTreeSetOidShort<IndexDescriptor>));
session.RegisterType(typeof(CompareByField<IndexDescriptor>));
session.RegisterType(typeof(Indexes));
session.RegisterType(typeof(VelocityDbList<OptimizedPersistable>));

```

For each of your classes that uses indexes (replace with your class name)

```

session.RegisterType(typeof(CompareByFieldIndex<InsuranceCompany>));
session.RegisterType(typeof(BTreeSetOidShort<InsuranceCompany>)); // short due to [OnePerDatabase] on this Index
// normally it would be instead
session.RegisterType(typeof(VelocityDb.Collection.Comparer.CompareByFieldIndex<Car>));
session.RegisterType(typeof(BTreeSet<Car>));

// If you are using Reference
session.RegisterType(typeof(Reference));
session.RegisterType(typeof(BTreeSet<Reference>));

```

If base classes have indexes (like Vehicle in this example), you need to do it for such classes as well.

Fixed size class instances and limiting string size

Objects of a class that has only fixed size fields can be stored without specifying an object size. This saves four bytes per object and such objects can in some cases be looked up by byte offset. You can make a string field fixed size by using the StringLength attribute as in

```

public class TickOptimized : OptimizedPersistable
{
    [StringLength(8)]

```

```
string m_symbol;
DateTime m_timestamp;
double m_bid;
```

In this case `m_symbol` will be stored using 8 bytes. We interpret length as number of bytes, not number of characters.

You can calculate how many bytes a certain string uses in persisted state with

```
SessionBase.TextEncoding.GetByteCount(string str);
```

Adding or removing field(s) from a class with existing objects in a database

After making changes to a class, in an update transaction call `session.UpdateClass(typeof(UpdatedClass))`; as done in the sample application [UpdateClass](#). This updates the schema to reflect the changes to your class, a new version of the class is created as a new instance of `TypeVersion`. Objects associated with prior versions of this type are migrated to the updated class in memory when read from a database. To make such objects permanently be shaped as the latest version of your class `TypeVersion`, you need to update the object with a call to `UpdateTypeVersion()`. If you fail to call `UpdateClass`, it can lead to exceptions and failures to read/write objects of the Type

Changing a field type without losing already persisted data

We wanted to make a change to our BTree/BTreeMap collection to reduce memory usage and improve performance. To do this while still preserving already persisted data of these types. This is how we did it.

First change class definitions by setting prior version usage field as `[NonSerialized]` and add new version of field as in:

```
[NonSerialized]
internal VelocityDbList<BTreeLeafBase<Key, Value>> nodeList;
internal WeakReferenceListBase<BTreeLeafBase<Key, Value>> _nodeList;
```

When we read an object of this type as it was before this change, `nodeList` will be set and `_nodeList` will be null so to make the switch to new field type add to this class code like:

```
public override void InitializeAfterRead(SessionBase session)
{
    base.InitializeAfterRead(session);
    if (nodeList != null)
    {
        _nodeList = new WeakReferenceList<BTreeLeafBase<Key, Value>>(nodeList.Count, Session);
        foreach (var e in nodeList)
            _nodeList.Add(e);
        if (session.InUpdateTransaction)
        {
            session.UpdateClass(GetType());
            UpdateTypeVersion();
            nodeList.Unpersist(session);
        }
    }
}
```

After updating all your persisted objects to the new field type, you can remove the `[NonSerialized]` field and the `InitializeAfterRead` override.

Renaming a persisted class or moving it to a different namespace

The `UpdateClass` sample shows how to do this.

Example usage

```
session.ReplacePersistedType(typeof(VelocityDbSchema.Samples.UpdateClass.UpdatedClass),  
typeof(UpdateClass.UpdatedClass));
```

and back again using alternate API

```
session.ReplacePersistedType(typeof(UpdateClass.UpdatedClass).AssemblyQualifiedName,  
typeof(VelocityDbSchema.Samples.UpdateClass.UpdatedClass));
```

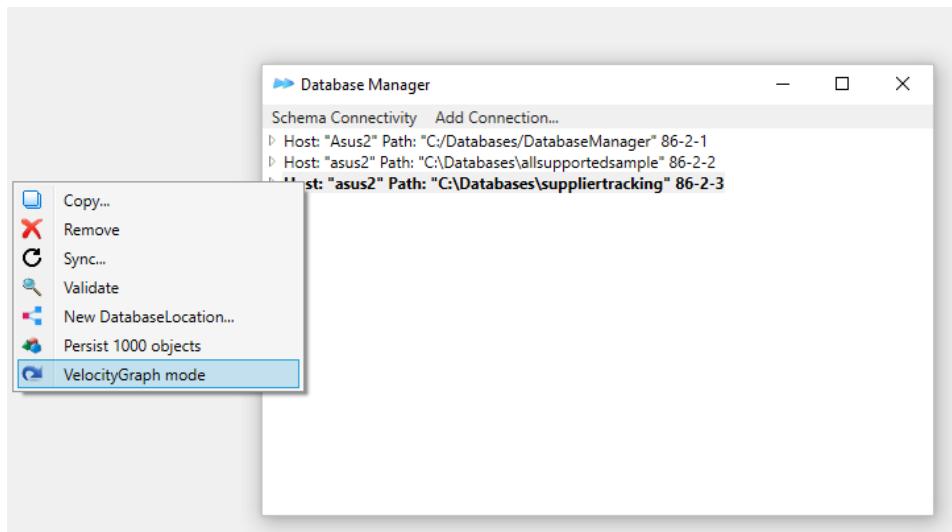
NOTE: The type you are replacing with must not already exist in the database schema. Make sure both old type and replacement type contains the exact same fields.

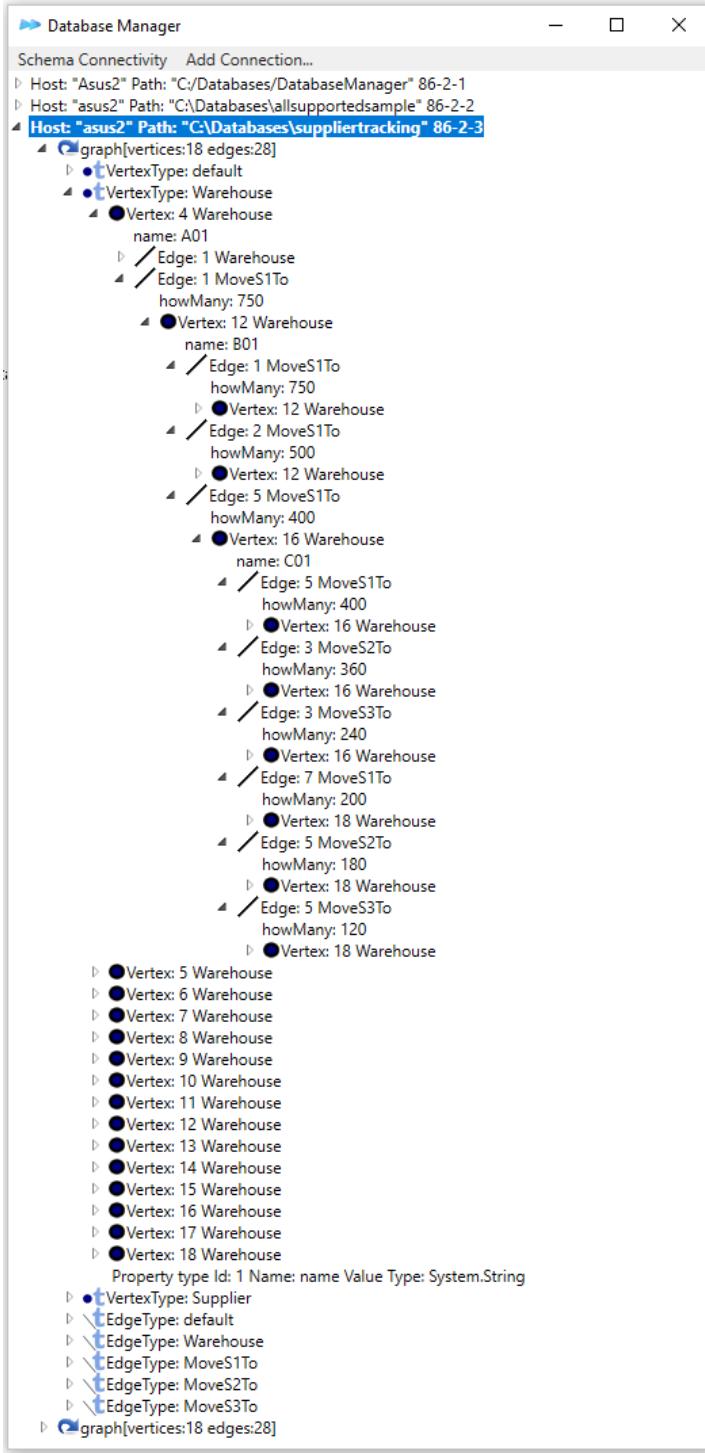
VelocityGraph

Some of the content in this guide does not apply to users that only use VelocityGraph with simple property values such as numbers and strings. As a strict VelocityGraph user you do not need to worry about calling Update() before updating an object and schema is static, only what the base VelocityGraph uses.

Visualizing a VelocityGraph

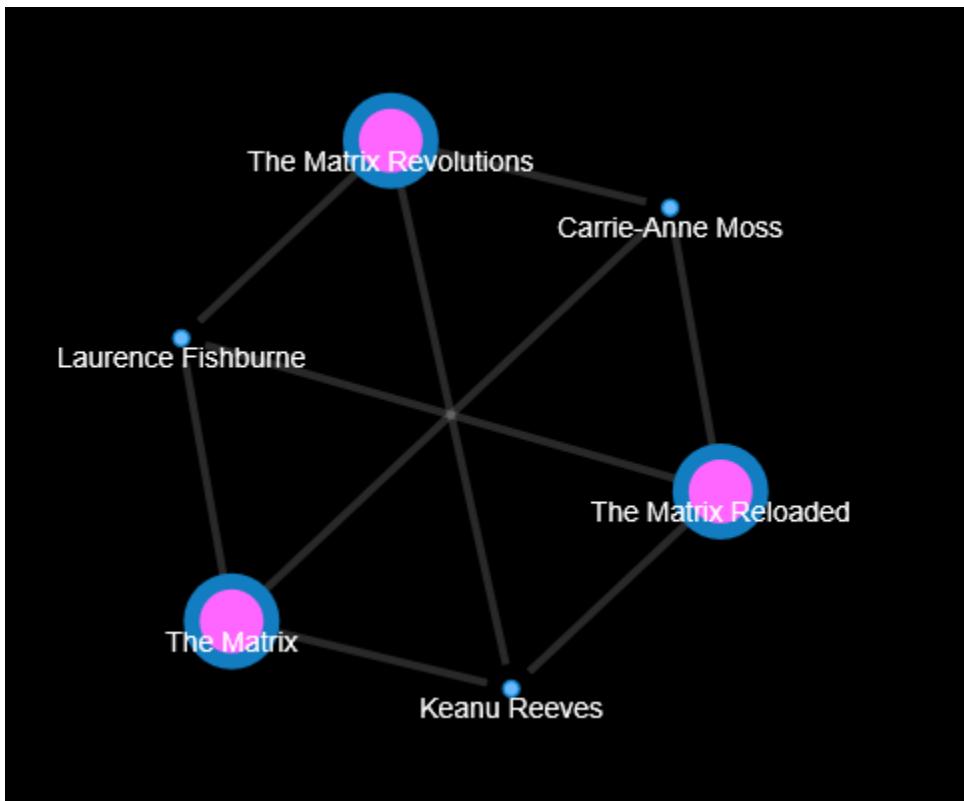
Our [DatabaseManager](#) now includes a **VelocityGraph mode**. Right click to bring up menu. In this mode you see objects as you work with them in VelocityGraph, the other mode (default) shows how objects are stored.



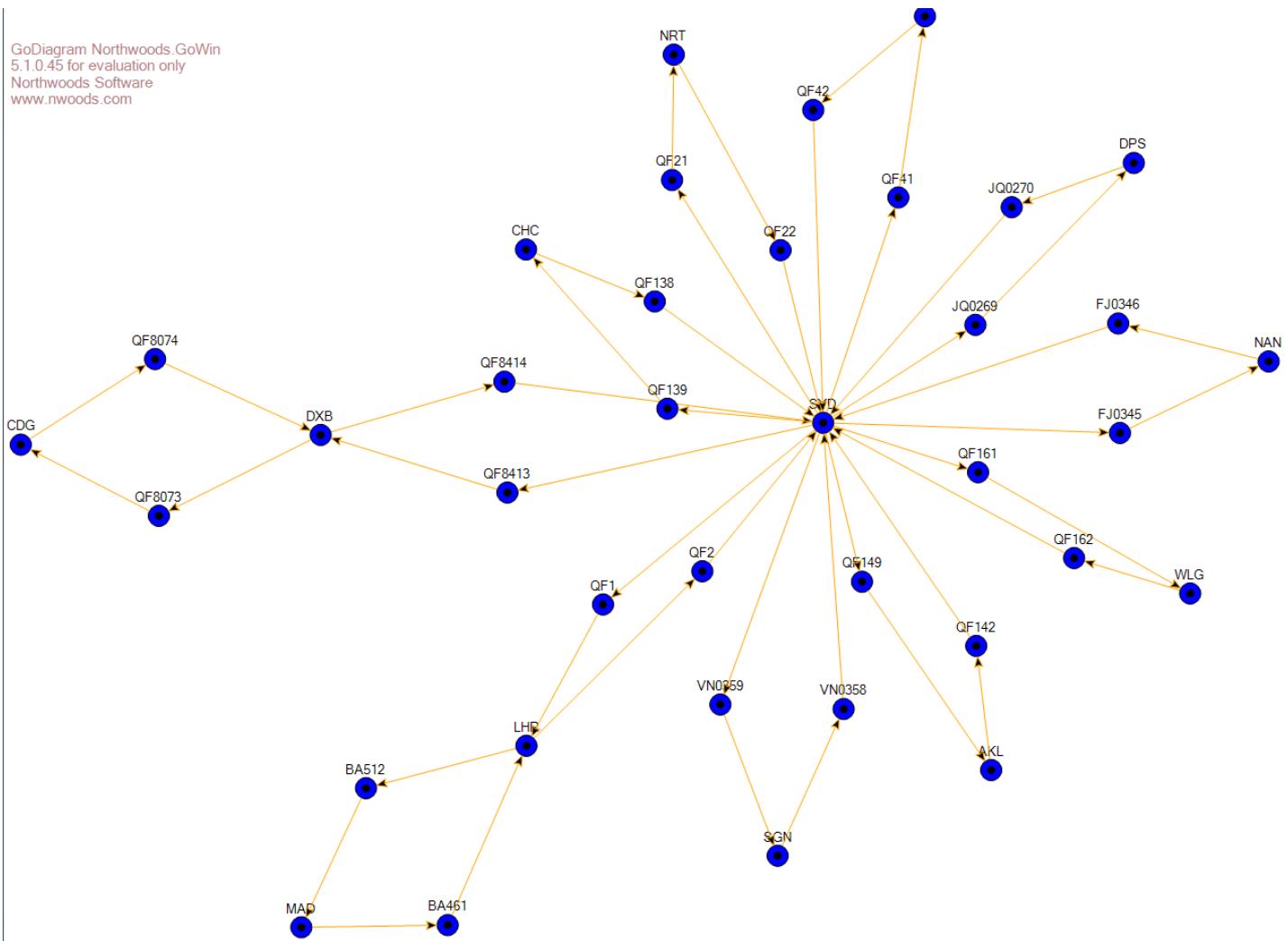


You can export a Graph to [GraphJson](#) and then use [Alchemy.js](#) to visualize the graph.

I.e. the exported graph of the QuickStart VelocityGraph can look like



Other alternatives include using [Northwoods Software](#). The following graph/diagram was created with very simple C# code from a VelocityGraph.



Persistent placement of objects

The placement (location) of persistent objects affects performance and locking. It is therefore important to make decisions about where to place an object when making it persistent. Once an object has been persisted, it remains in the same location for its persistent life time. You can decide how many objects you want on a single page. For slightly improved storage, require that a page only may contain objects of a specific type. Also fixed size objects (ones with no contained variable size arrays) can further improve object store efficiency. Several ways of controlling the placement when persisting object are provided. First on [IOptimizedPersistable](#) the following helps guide the placement:

```
UInt16 ObjectsPerPage
{
    get;
}
```

Best way to persist an object

The recommended way of persisting objects is using the [SessionBase](#) api:

```
public UInt64 Persist(object obj)
```

When this api is used, each type is stored in its own database. For **best performance** avoid explicitly persisting objects unless: an object is a root object (not referenced by other persisted objects), includes an [\[AutoIncrement\]](#) field (unless you don't care what number gets assigned), used in a VelocityDBWeakReference or is indexed and you can't wait for the

index update to happen at transaction commit. Objects not persisted explicitly will be made persistent automatically by reachability from a persisted object.

Add the attribute `[NonSerialized]` for each class field you don't want to be persisted.

It is recommended that you make the following override in your `OptimizedPersistable` subclass for better performance:

```
public override bool AllowOtherTypesOnSamePage
{
    get
    {
        return false;
    }
}
```

We may make this default but it could break existing code so it is not a trivial change.

Customizing object placement (most of you can skip this part)

In addition the `IOptimizedPersistable` interface contains API intended for customizing how fields of an object being persisted are to be persisted (including where to place).

```
UInt64 Persist(Placement place, SessionBase session, bool persistRefs = false, bool disableFlush = false);

UInt64 Persist(SessionBase session, IOptimizedPersistable placeHint, bool persistRefs = false, bool disableFlush = false);
```



```
for (int i = 0; i < numberOfPersons; i++)
{
    person = new Person();
    person.Persist(session, person);
}
```




```
for (int i = 0; i < numberOfPersons; i++)
{
    person = new Person();
    if (priorPerson == null)
        priorPerson = person;
    person.Persist(session, priorPerson); // use prior person as object to persist near
    priorPerson = person;
}
```

The second way of controlling the placement while persisting an object is by using persistent or transient instances of the `Placement` class.

```

public Placement(UInt32 db, UInt16 page = 1, UInt16 slot = 1, UInt16 objectsPerPage = 10000, UInt16
pagesPerDatabase = 10000, bool persistRefs = false, bool tryOtherDatabaseIfLockConflict = true, UInt32
maxNumberOfDatabases = UInt32.MaxValue, bool allowOtherTypesOnSamePage = true, bool flushFullPages =
true)

public Placement(SessionBase session, IOptimizedPersistable placementProviderObject,
IOptimizedPersistable objectToPlace, bool persistRefs = false, UInt32 maxNumberOfDatabases =
UInt32.MaxValue, bool flushFullPages = true)

```

There is also additional API on `Placement` for fine tuning the placement. An instance of `Placement` is used as parameter to the `IOptimizedPersistable` Persist API mentioned above.

Sometimes it's an advantage to put all related objects in a single database because then 32bit, `OidShort`, object references can be used instead of full 64 bit, `Oid`, object references. A short object reference contains only a page and slot part (16 bit each). Such references use less storage space and if only short references are used within a database, such a database can easily be cloned since it's database number isn't hard coded anywhere within the database. Short references are not automatically used when you place objects this way. The application must explicitly request it in the class definition by using the attribute `[UseOidShort]`. There are also special short references versions of the provided BTree collections. The application needs to use those instead of the long reference BTree collections when you want all objects within a database to use short references.

How to optimally place/persist objects is application dependent. The sample programs provided try to illustrate some of many use cases for object placement.

Controlling placement of objects persisted by reachability

By default when you persist some object using the [recommended method](#), all objects reachable from this object are also persisted by the same method. You can override this behavior for persisting reachable objects by overriding the property `IOptimizedPersistable.PlacementDatabaseNumber` to return something different than `Placement.DefaultPlacementDatabaseNumber`.

You can further control the persist of objects by overriding the `Persist` function as in:

```

public override UInt64 Persist(Placement place, SessionBase session, bool persistRefs = true, bool
disableFlush = false, Queue<IOptimizedPersistable> toPersist = null)
{
    base.Persist(place, session, false, disableFlush, toPersist);
    keyArray.Persist(place, session, true, disableFlush, toPersist);
    return Id;
}

```

Looking up objects

The most efficient way is to have one or a few root objects that you look up by the object identifier as in:

```
ImdbRoot imdbRoot = (ImdbRoot)session.Open(session.DatabaseNumberOfType(typeof(ImdbRoot)), 2, 1, false);
```

When you open an object this way, all objects referenced by the object is also connected to the object so then to reach related objects all you need to do is navigate to related objects such as in:

```
imdbRoot.ActingByNameSet
BTreeSet<Word> wordSet = indexRoot.lexicon.wordSet;
```

Another way to lookup objects is by using a LINQ query such as:

```
var result = (from ComputerFileData computerFileData in session.AllObjects<ComputerFileData>()
             where computerFileData.FileID == 500000
             select computerFileData).First();
```

or you can accomplish the same lookup without using LINQ as:

```
var computerFileDataEnum = session.AllObjects<ComputerFileData>();
foreach (ComputerFileData computerFileData in computerFileDataEnum)
{
    if (computerFileData.FileID == 500000)
        break; // found it
}
```

The third way is by looking up from a collection (usually a BTree) as in:

doc.WordHit.TryGetValue(word, **out** wordHit) or via an [index lookup](#).

DO NOT reference persistent data using static variables

It is not OK to have variables like

```
static VertexType movieType;
static PropertyType movieTitleType;
static PropertyType movieYearType;
```

Updating persistent objects

VelocityDB need to be notified when you want a change to an object to be persisted. The safest way to do this, is to define a property for every field your application data objects have, such as:

```
[FieldAccessor("m_bestFriend")]
public Person BestFriend
{
    get
    {
        Session?.LoadFields(); // Loads all fields of an object if they are not already loaded.
        return m_bestFriend;
    }
    set
    {
        Update(); // IMPORTANT, call Update() before updating object
        m_bestFriend = value;
    }
}
```

If updating a field that is NOT indexed you can avoid the index update cycle by calling the object update function on `SessionBase` instead of `OptimizedPersistable` `Update()` as in

```
public string StreetAddress
{
    get
    {
        return m_streetAddress;
    }
    set
    {
        UpdateNonIndexField();
        m_streetAddress = value;
    }
}
```

Note - Do not use any VelocityDB API between `Update()` and the field update or a VelocityDB API as part of the field update otherwise the update may not be persisted as this can cause the object page to be flushed.

VelocityDB collection classes like `VelocityDbList<T>`, `BTreeset<Key>` and `BTreeMap<Key, Value>` calls update automatically internally so you don't need and should not call `Update()` when modifying such collections.

When updating objects that are not implementing `IOptimizedPersistable`, call `session.UpdateObject`.

`BindingList<MyItem>` is such a case. Exception are: `List<>`, arrays and `ValueType` objects when embedded in an object that implements `IOptimizedPersistable`. For such lists call `Update()` on the object embedding the list.

```
public class MyContainer : OptimizedPersistable
{
    private BindingList<MyItem> m_items;
    public BindingList<MyItem> Items {
        get { return m_items; }
    }

    public MyContainer()
    {
        m_items = new BindingList<MyItem>();
    }

    public bool UpdateBindingList(SessionBase session)
    {
        return session.UpdateObject(m_items);
    }
}
```

Deleting (unpersisting) persistent objects

Use `OptimizedPersistable.Unpersist` or `Page.UnpersistObject` or `SessionBase.DeleteObject`. You can override the default implementation of `public virtual void Unpersist(SessionBase session, bool disableFlush = true)`, i.e.

```
public override void Unpersist(SessionBase session, bool disableFlush = true)
{
    if (id == 0)
        return;
    if (comparisonByteArrayId != 0)
    {
        comparisonBytesTransient = (BTreeByteArray)session.Open(comparisonByteArrayId);
        comparisonBytesTransient.Unpersist(session, disableFlush);
        comparisonByteArrayId = 0;
    }
    nodeList.Unpersist(session, disableFlush);
    base.Unpersist(session, disableFlush);
}
```

Referential integrity

When removing an object from a database, it is important that references to this object also are removed. Otherwise such references may end up referencing some other object or become a null reference.

It is recommended that you maintain two way relation (bidirectional) as much as possible because that makes it easier to cleanup references and also to diagnose dangling references when they occur.

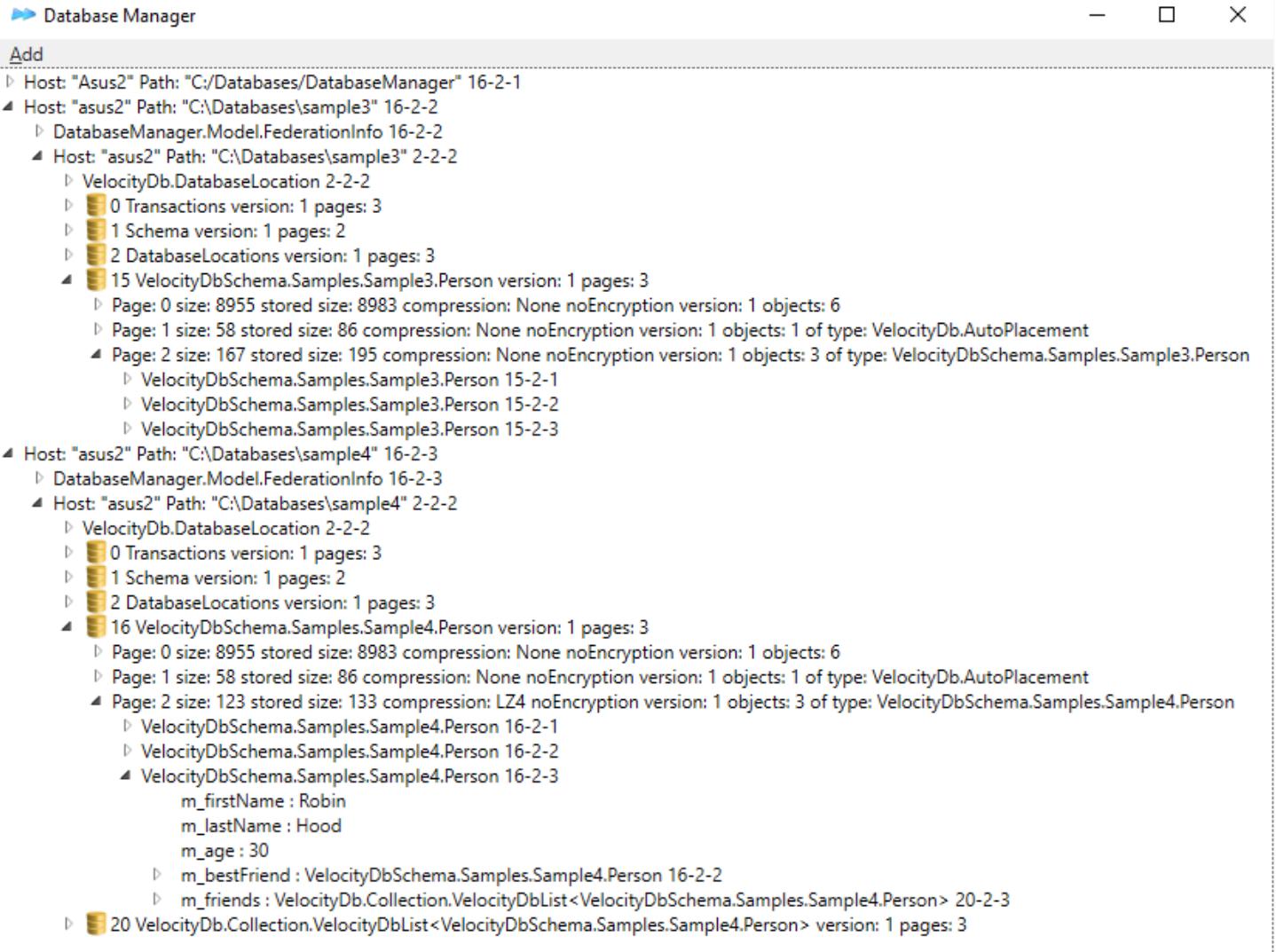
Interface `IReferenceTracked` and class `ReferenceTracked` was added as an aid to maintain referential integrity. A simple sample project named Relations shows how this API can be used.

Collection Classes

List<T> vs VelocityDbList<T>

With VelocityDBList, each list gets an Id, with List not. You can share VelocityDbList between multiple objects, not List.

Sample3 uses List, Sample4 uses VelocityDbList. See difference in DatabaseManager below. Sample4 has a database 20 containing VelocityDbList objects.



Avoid using Dictionary, HashSet and any other ISerializable classes

Serialization and deserialization are highly efficient with VelocityDB but when a class implements ISerializable that optimization is lost, and we must use the custom code for serialization and deserialization the type provides as methods.

For Dictionary that code is:

```
protected Dictionary<SerializationInfo, StreamingContext> info, StreamingContext context) {
    //We can't do anything with the keys and values until the entire graph has been deserialized
    //and we have a resonable estimate that GetHashCode is not going to fail. For the time being,
    //we'll just cache this. The graph is not valid until OnDeserialization has been called.
    HashHelpers.SerializationInfoTable.Add(this, info);
}

[System.Security.SecurityCritical] // auto-generated_required
public virtual void GetObjectData(SerializationInfo info, StreamingContext context) {
```

```

if (info==null) {
    ThrowHelper.ThrowArgumentNullException(ExceptionArgument.info);
}
info.AddValue(VersionName, version);

#if FEATURE_RANDOMIZED_STRING_HASHING
info.AddValue(ComparerName, HashHelpers.GetEqualityComparerForSerialization(comparer), typeof(IEqualityComparer<TKey>));
#else
info.AddValue(ComparerName, comparer, typeof(IEqualityComparer<TKey>));
#endif
info.AddValue(HashSizeName, buckets == null ? 0 : buckets.Length); //This is the length of the bucket array.
if( buckets != null) {
    KeyValuePair<TKey, TValue>[] array = new KeyValuePair<TKey, TValue>[Count];
    CopyTo(array, 0);
    info.AddValue(KeyValuePairsName, array, typeof(KeyValuePair<TKey, TValue>[]));
}
}

```

This also makes the objects use up more space as persistent. Instead of persisting Dictionary use VelocityDB collection [BTreeMap](#) and instead of HashSet use [BTreeSet](#).

Using the provided BTree collections

Just about all object oriented applications need to use collections. VelocityDB provides [BTree](#) collections which are similar to BTree's of the variety B*. A BTree is a collection where the added objects are sorted. An application can define the sort order by defining a subclass of [VelocityDbComparer<Key>](#) or by using the class [CompareByField<Key>](#), a collection may also have a [null](#) comparator in which case the objects are ordered by the object identifier or by the [ValueType](#) ordering as defined by the objects [public override int CompareTo\(object obj\)](#) implementation. The BTree comes in a few varieties, a key only version and a key value version. They also have a long object Id (db-page-slot) version and a short Id (page-slot) version. A BTree can be used with comparisonByteArray data which is used to cache object key data within the BTree nodes so that when a binary search takes place we can avoid opening objects to compare. When you use the predefined class [CompareByField<Key>](#) it is easy to add comparisonByteArray data to the BTree nodes, you just specify how many bytes per object it should be and whether the cached node byte contains the entire data being compared when deciding if one object is less, equal or greater compared to another. If you customize building your own comparator, managing the comparisonByteArray becomes a little trickier; on the compare class you need to define [SetComparisonArrayFromObject](#) as in:

```

public override void SetComparisonArrayFromObject(Word key, byte[] comparisonArray, bool oidShort)
{
    Int32 hashCode = key.aWord.GetHashCode();
    Buffer.BlockCopy(BitConverter.GetBytes(IPAddress.HostToNetworkOrder(hashCode)), 0, comparisonArray,
0, comparisonArray.Length);
}

```

In this case we are sorting by the hash code of a string, the corresponding compare function in this case looks like:

```

public override int Compare(Word a, Word b)
{
    UInt32 aHash = (UInt32) a.aWord.GetHashCode();
    UInt32 bHash = (UInt32) b.aWord.GetHashCode();
    int value = aHash.CompareTo(bHash);
    if (value != 0)
        return value;
    return a.aWord.CompareTo(b.aWord);
}

```

A problem here is that a String GetHashCode() returns different values on a 32 bit platform then a 64 bit platform. To make your data cross platform compatible don't use the string GetHashCode, instead build your own string hash code function. We do so in the VelocityDB build in class [HashCodeComparer<T>](#).

Btree classes provided:

- [BTreeSet<Key>](#)
- [BTreeSetOidShort<Key>](#)

- `BTreeMap<Key, Value>`
- `BTreeMapOidShort<Key, Value>`

Sample usage:

```
public Lexicon(ushort nodeSize, HashCodeComparer<Word> hashComparer, SessionBase session)
{
    wordSet = new BTreeSet<Word>(hashComparer, session, nodeSize);
}
```

[BTreeMap<Key, Value>](#)

Represents a collection of keys that is maintained in sorted order. Each key has an associated value. A persistent BTree references its contained objects by Oid instead of direct object references. This way, we will only open the referenced objects on demand which reduces memory usage and initial BTree load time. Exceptions are ValueType keys and values.

For more see <https://velocitydb.com/Help/html/f12b67ba-577a-7b2e-43a4-d489688f753e.htm>

Indexes

Indexes is a simplified, automated, way of implicitly defining and keeping `BTreeSet<Key>`s up to date when objects are added, deleted and updated. An index is defined by using the class or field [`Index`] attribute. Indexes for a persistent Type is stored in its own system selected database, the range of databases used is between 66000 up to 66000 + the number of Types and versions of a type that your application store persistently. An object gets added to its indexes when an object is persisted. Make sure to set all indexed fields to desired indexed values before persisting object. When an indexed object is updated, its indexes get updated when the page of the objects gets flushed to disk. You can force it to be flushed to disk and have the index updated by calling `Write()` on the object you updated (after you made the changes and object is an `OptimizedPersistable`). If you made a change that does not affect the index, you did not modify an indexed field, you don't need to update the index explicitly since the index is unaffected. An object is removed from its indexes when it is unpersisted and when `Update()` is called. If you want to index objects separately for each Database, tag the class or field with the attribute [`OnePerDatabase`]. Before modifying an indexed field, it is important to call `Update()` on the object having the field before doing the update because the object needs to be removed from its indexes before updates or else the removal code will fail to find the object in its indexes leading to an index corruption. Call `FlushUpdates()` or `FlushUpdates(Database db)` on the session after the changes have been made to add it back to indexes. Use only with subclass of `OptimizedPersistable`.

Using a worker thread to add indexed objects to its indices

Starting in VelocityDB 4.5, we added a feature that reliefs the main database thread from the work of adding objects to indices. This feature is available with `SessionNoServerShared`. You can make the indexing happen in the main database thread by setting `session.AddToIndexInSeparateThread = false;` If object indexed contains an [`OnePerDatabase`] index then indexing will happen in main session thread.

Class level index

When you want an index with compound keys, like order by `lastName` and then if two or more `lastnames` are equal by `firstName` and if two or more `firstNames` are equal, order these otherwise equal objects by yet another field name and so on. We currently only allow one class level index (by multiple compound keys) per class.

```
[Index("modelYear,brandName,modelName,color")]
public abstract class Vehicle : OptimizedPersistable
{
    string color;
    int maxPassengers;
    int fuelCapacity; // fuel capacity in liters
    double litresPer100Kilometers; // fuel cunsumption
```

```
DateTime modelYear;
string brandName;
string modelName;
int maxSpeed; // km/h
int odometer; // km
```

You can also use the class level Index attribute without specifying any field names; in that case the contained objects are sorted by the default ordering of the class which is normally by Oid (Id).

Using a class level index

To iterate all Cars in index sorted order

```
foreach (Car c in session.Index<Car>())
    Console.WriteLine(c.ToStringDetails(session));
```

Index by a field

This type of index sorts all persistent instances of a class by a field value. Note that in order to use this type of index in a LINQ query, you need to tell us what property that returns the value of the field. You do that by the [FieldAccessor](#) attribute as in sample class below. The [\[UniqueConstraint\]](#) attribute can be added when you don't want multiple objects with the same field value in the index. An exception is raised if you add a second object with the same field value when [\[UniqueConstraint\]](#) is applied to the field. The [\[IndexStringByHashCode\]](#) attribute can also be added to string field indexes when you don't care about the sort order. Sorting by hash code is faster than sorting by the normal string ordering.

```
public class InsuranceCompany : OptimizedPersistable
{
    [Index]
    [UniqueConstraint]
    [OnePerDatabase]
    string name;
    string phoneNumber;

    public InsuranceCompany(string name, string phoneNumber)
    {
        this.name = name;
        this.phoneNumber = phoneNumber;
    }

    [FieldAccessor("name")]
    public string Name
    {
        get
        {
            return name;
        }
    }
}
```

Using the index by field in a LINQ query

In every source file that uses an index in a query, it is important to have

```
using static VelocityDBExtensions.Extensions.BTree.BTreeExtensions;
```

This activates the BTree extension methods that overrides the default Enumerable versions. You should see much improved performance when using the extension methods. The following extensions methods are defined:

```
static public IEnumerable<Key> Where<Key>(this BTreeBase<Key, Key> sourceCollection,
Expression<Func<Key, bool>> expr)
```

```
static public int Count<Key>(this BTreelBase<Key, Key> sourceCollection)
```

Let us know if you want other “slow” method overrides of Enumerable with BTreel.

The extensions are located in a separate assembly, so you will also need to add a reference to it or use the VelocityDBExtensions NuGet.

If you don’t want to drag in all the additional assembly references, we are currently duplicating the BTreel extensions code within the VelocityDB assembly.

So you can use `using static VelocityDb.Collection.BTree.Extensions.BTreeExtensions;` instead to avoid these additional dependencies. We put this code in the open source VelocityDBExtensions so that YOU could help us improve this complicated expression tree code! Any assistance is appreciated and will be rewarded with a VelocityDB license discount.

```
var q = from company in session.Index<InsuranceCompany>("name")
where company.Name == "AAA" select company;

foreach (InsuranceCompany company in q)
    Console.WriteLine(company.ToStringDetails(session)); // only one will match
```

Enable index usage trace

Not every LINQ query will end up using the fast path with direct index lookups instead of the default Enumerable. Where, this can be because your query contains non indexed fields or because the linq query somehow does not match the Enumerable. Where extension provided with VelocityDB. To find out, enable index tracing by calling `session.TraceIndexUsage = true;`. If index is used by a query then you will see output to Console like:

```
20:42:12:982 Index used with BTreelSet<Country> 66206-1-1
```

If index is not used, there will be no output to Trace. If you also want output to Console add the code:

```
Trace.Listeners.Add(new ConsoleTraceListener());
```

Simplify the query as much as possible

The following query will use the fast path

```
BTreeSet<Country> countryIsoIndex = session.Index<Country>("ISO");
string homeCountry = (string)airline_element.Element("Home_Country");

var res_country_q = from country in countryIsoIndex
                    where country.I_ISO == homeCountry
                    select country;
Country res_country = res_country_q.FirstOrDefault();
```

The following equivalent will use the slow non VelocityDB enumeration. The thing that makes it not use the VelocityDB extension is specifying the type of country (`Country country`). Leave it out and it will be much faster! Anyone knows why???

```
var res_country = (from Country country in session.Index<Country>("ISO")
                    where country.I_ISO == (string)airline_element.Element("Home_Country")
                    select country).First();
```

Changing indexing for a class after objects of that type already persisted

Changing indexing is handled the same way as any changes to a class definition. For example, if you start out with the following class definition and you commit some

```
[Index("modelYear,brandName,modelName,color")]
public abstract class Vehicle : OptimizedPersistable
```

```
{
[Index]
string color;
int maxPassengers;
int fuelCapacity; // fuel capacity in liters
[Index]
double litresPer100Kilometers; // fuel consumption
[Index]
[UniqueConstraint]
Guid guid = Guid.NewGuid();
DateTime modelYear;
[Index]
[IndexStringByHashCode]
string brandName;
string modelName;
List<VelocityDbSchema.Person> owners;
int maxSpeed; // km/h
int odometer; // km
```

AND later change it to

```
[Index("modelYear,brandName,modelName,color")]
public abstract class Vehicle : OptimizedPersistable
{
    string color;
    int maxPassengers;
    int fuelCapacity; // fuel capacity in liters
    [Index]
    double litresPer100Kilometers; // fuel consumption
    [Index]
    [UniqueConstraint]
    Guid guid = Guid.NewGuid();
    DateTime modelYear;
    [Index]
    [IndexStringByHashCode]
    string brandName;
    string modelName;
    List<VelocityDbSchema.Person> owners;
    int maxSpeed; // km/h
    [Index]
    int odometer; // km
```

You will need to convert all your existing Vehicle objects to this updated class definition.

```
session.UpdateClass(typeof(Vehicle));
foreach (var v in session.AllObjects<Vehicle>())
{
    v.UpdateTypeVersion();
}
```

This code will remove all Vehicle objects from the “string color” index and will create a new index and add all Vehicle to “int odometer” index.

System.OutOfMemoryException

Make sure that your process is not running as a 32-bit process on a 64-bit Windows, as a 32-bit process you will get the OutOfMemoryException at around 1.5 GB. Use the Task Manager as a way to determine if your process runs as a 64bit process. 32-bit processes has their name appended with the string “(32 bit)”, also do not use the “Visual Studio Hosting Process” – it’s in your projects Debug options - if it is running as a 32 bit process. If your project is using .NET 4.5 make sure that you do not have the option “Prefer 32 bit” set. If this isn’t set but your process still is 32 bit then change to use

.NET 4.0 as a work around. If you absolutely need to run your process as 32-bit then tell VelocityDB to limit its caching by setting: `DataCache.MaximumMemoryUse = 1100000000`; to limit the memory usage.

Limits graph of objects in memory

When an object is opened by a session object, all object referenced by that object are also brought into memory. In some cases that isn't desired. You can limit the size of such graphs by using WeakReferenceList or the BTree collections which avoids bringing in all the contained objects. These collections avoids bringing in all referenced objects by not having straight forward C# object references everywhere; instead references are replaced by the object identifier of the referenced object, as in:

```
internal UInt64 comparisonByteArrayId;
internal UInt64[] keysArray;
internal UInt64[] valuesArray;
```

Here each `UInt64` is the Id of some persistent object. The BTree fetches such objects on demand:

```
internal override Key GetKey(int index)
{
    if (IsPersistent && UseAlternateKeys == false)
        return Session.Open<Key>(keysArray[index]);
    else
        return keysArrayAlternate[index];
}
```

For single non array references VelocityDB provides `WeakIOptimizedPersistableReference<T>` as in:

```
aMan.spouse = new WeakIOptimizedPersistableReference<VelocityDbSchema.Person>(aWoman);

to get the value use public T GetTarget(bool update, SessionBase session).
```

You can examine how large a loaded object graph might be by examining the Schema Type Connections using the [Database Manager](#).

Implementing your own classes with weak references

Here is one example that we use with the AllSupported sample project.

```
public class WeakReferencedConnection<T> : OptimizedPersistable where T : OptimizedPersistable
{
    UInt64 _objId;
    static WeakReferencedConnection()
    {
        var list = new List<Type> { typeof(T) };
        Schema.WeakReferencedTypes[typeof(WeakReferencedConnection<T>)] = list; // register this weak
reference with schema so that DatabaseManager can recognize this as being a weak referenced object
    }

    public WeakReferencedConnection(T t)
    {
        if (!t.IsPersistent)
            throw new PersistedObjectExcpectedException("Persist first");
        t.Session.Persist(this);
        _objId = t.Id;
    }

    public T MyWeakReferencedObject
    {
        get
        {
            return Session.Open<T>(_objId);
```

```
    }
}
}
```

Using only weak references between objects

A benefit of using only weak references is that object caching can be optimized. If your application only uses weak references, such as the case with schema used with VelocityGraph, you can set:

```
SessionBase.ClearAllCachedObjectsWhenDetectingUpdatedDatabase = false;
```

This way you preserve object cache for objects in databases that are up to date in cache. Only objects in a database that is found to have been updated by another transaction is invalidated. This can be a significant performance boost depending on how often updates occur.

Lazy load of object references

Another way of limiting what gets loaded when an object is open is the `LazyLoadMembers` property on `OptimizedPersistable`

```
/// <summary>
/// By default all fields are loaded when opening a persistent object but an option is provided to load
/// members on demand (lazy loading).
/// </summary>
public virtual bool LazyLoadFields
{
    get
    {
        return false;
    }
}
```

When a class uses lazy loading of fields, each field access must make sure the field is loaded first.

```
public LazyLoadPropertyClass MyRef
{
    get
    {
        Session?.LoadFields();
        return myRef;
    }
    set
    {
        Update();
        myRef = value;
    }
}
```

Specifying depth to load at object open

An alternative to the lazy load property is to specify depth to load at object open.

```
LazyLoadByDepth lazy = (LazyLoadByDepth)session.Open(id, false, false, 0); // load only the root of the object graph
```

Session caching of databases, pages and slots

Each session object maintains a cache of databases, pages and slots. The caching is mostly using weak references. Database pages also have a strong reference cache which is released when available memory is low. By default objects and pages are cached with strong references, unless you override the session constructor parameters for this, but if an object's class overrides the `Cache` property, object caching may not happen for that type of objects. If a cashed Database

is found to be out of date, all objects cached are released (even objects cached for other Databases). This is to be sure we don't end up using stale objects indirectly via object references.

Strong reference caching can be disabled by creating the session instance with a parameter that disables caching. Avoid having strong references to persistent object between transactions since a strong referenced object cannot be updated in case the object was updated by another session. Look up persistent objects from scratch in each new transaction so that stale objects can be avoided.

Here is an example of how to create a session without strong referenced page cache and without string object cashing:

```
using (SessionNoServer session = new SessionNoServer(s_systemDir, 5000, optimisticLocking: false,  
enablePageCache: false, objectCachingDefaultPolicy: CacheEnum.No)) {}
```

Some sections of your code might benefit from object/page caching while other sections do not. You can control the caching as done below.

```
session.ObjectCachingDefaultPolicy = CacheEnum.No; // the following processing works faster without  
object caching when < 40GB memory not available  
session.ClientCache.PageCacheEnabled = true; // strong reference page caching is beneficial in this  
case
```

It is also possible to enable object/page caching for selected databases. These settings don't persist, it is just until such objects/pages are purged from memory due to memory usage limitations or due to updates from other transactions. Such selected settings are useful when ingesting a billion objects with indexing. Turn on caching of indexing objects and its pages but not for the billion objects!

```
root.Page.Database.PageCacheEnabled = true;  
root.GeoHashToNode.Page.Database.PageCacheEnabled = true;  
UInt32 dbNum = session.DatabaseNumberOf(typeof(BTreeLeaf<Int64, Node>));  
Database db = session.OpenDatabase(dbNum, false, false);  
if (db != null)  
    db.PageCacheEnabled = true;  
root.Page.Database.ObjectCachingDefaultPolicy = CacheEnum.Yes;  
root.GeoHashToNode.Page.Database.ObjectCachingDefaultPolicy = CacheEnum.Yes;
```

Databases are cached using weak references by default but you can force use of strong references to existing databases using api on SessionBase.

```
session.CrossTransactionCacheAllDatabases();
```

```
session.CrossTransactionCache(db, true);
```

Diagnostics

When you notice that something isn't the way it should be, maybe something is taking longer than expected, there is useful option you can turn on that logs all activities related to all database files or files of selected databases.

To turn on tracing for a specific database (in this case database 55), use SessionBase api:

```
session.SetTraceDbActivity(55);
```

To turn on tracing of all databases use: `session.SetTraceAllDbActivity();`

Handling exceptions thrown by VelocityDB

A VelocityDB application should handle exceptions thrown by the VelocityDB kernel.

```
try
```

```

{
  using (SessionNoServer session = new SessionNoServer(systemDir))
  {
    session.BeginRead();
    ...
    session.Commit();
  }
}
catch (Exception ex)
{
  Console.WriteLine(ex.ToString());
}

```

Here is a list of the current possible VelocityDB exceptions:

```

AlreadyInCommitException
AlreadyInTransactionException
DatabaseAlreadyExistsException
DatabaseDoesNotExistException
DatabaseReadLockException
DesKeyMissingException
FieldDoesNotExistException
IndexDatabaseNotSpecifiedException
IndexDatabaseOrBTreeMissingException
IndexDatabaseSpecifiedForGlobalIndexException
InternalErrorException
InTransactionException
InUpdateTransactionException
InvalidChangeOfDatabaseLocation
InvalidChangeOfDefaultLocationException
MaxNumberOfDatabasesException
NotInTransactionException
NoValidVelocityDBLicenseFoundException
NullObjectException
ObjectDoesNotExistException
ObjectNotInSameDatabaseAsOidShortCollectionException
OpenDatabaseException
OptimisticLockingFailed
PageDeadLockException
PageDoesNotExistException
PageReadLockException
PageUpdateLockException
PersistedObjectExpectedException
RequestedPlacementDatabaseNumberNotValidException
RequestedPlacementPageNumberNotValidException
SubscriptionsNotAvailableWithNoServerSessionException
SystemDatabaseNotFoundWithReadOnlyTransactionException
TryingToBeginReadOnlyTransactionWhileInUpdateTransactionException
TryingToDeleteDeletedDatabaseException
UnexpectedException
UniqueConstraintException
UpdateLockFailedException
WeakReferenceMustBePersistentException

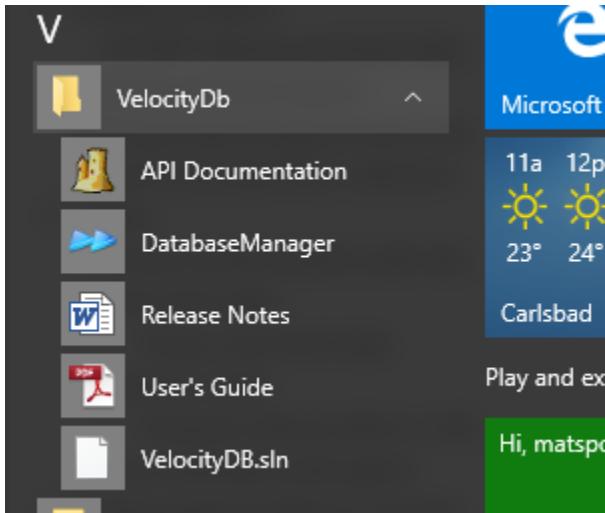
```

Database Manager

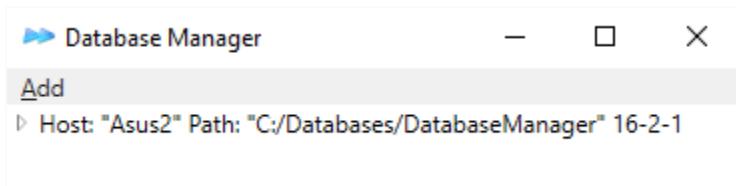
Use DatabaseManager for administrating all your databases. Using Database Manager is a great way to inspect your data, making sure it looks the way you expect it. DatabaseManager is available in the sample VelocityDB.sln provided with the VelocityDB download.

Starting Database Manager

Startup Database Manager (it is in your Start menu). Before you start it you may want to look at DatabaseManager.exe.config in your installation folder and change settings to fit your case. You also want to put your VelocityDB license database, 4.odb, into the DatabaseManager database folder.



An initial admin database is created. This database contain info about all other databases you “Add” to the Database Manager.



Objects are initially lazy loaded

This means you will need to make sure your objects are fully loaded when the object `ToString` method is called. If you override `Tostring()` and it uses non primitive fields to render string, first call `Session.LoadFields(this);` to make sure all required fields are loaded.

Objects are automatically loaded once you drill down into child objects.

Browsing objects created by Baseball sample application.

Click on the “Add” menu item.

VelocityDB Connection

Database Directory C:\Databases\baseball Browse...	Assemblies Classes Assemblies C:\VelocityDB\Debug\VelocityDbSchema.dll Remove Add	Restore From Backup Directory Host <input type="text"/> Database Number 100000000 Restore up to <input type="text"/> Select a date
Session Details <input checked="" type="radio"/> Not using VelocityDBServer <input type="radio"/> Using VelocityDBServer Host <input type="text"/> <input type="checkbox"/> Pessimistic Locking <input type="checkbox"/> Use Windows Authentication <input type="checkbox"/> Create New (if system databases missing) WaitForMilliseconds <input type="text"/> 5000	Dependency Assemblies Remove Add	

Click **Browse...** to find the directory of your Baseball databases (build & run this sample first if you have not) then add the VelocityDbSchema.dll to list of classes assemblies and click OK button. Click on arrows to expand.

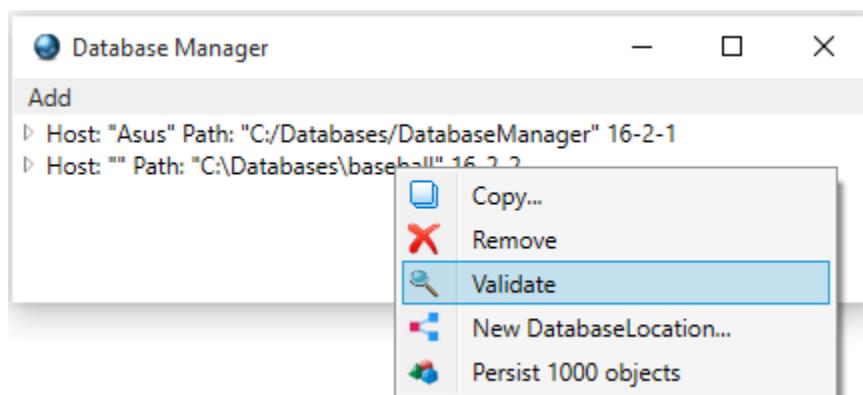
Database Manager

Schema Connectivity Add Connection...

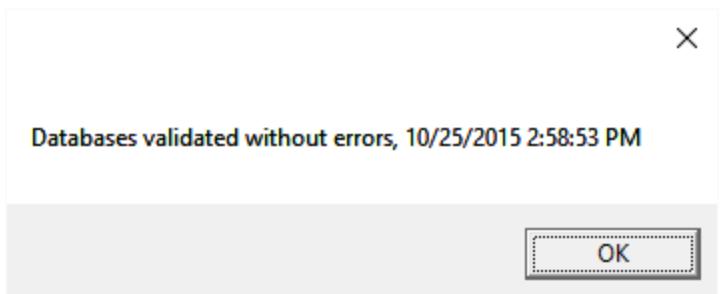
- ▷ Host: "Asus2" Path: "C:/Databases/DatabaseManager" 86-2-1
- ▷ Host: "asus2" Path: "C:\Databases\allsupportedsample" 86-2-2
- ☛ Host: "asus2" Path: "C:\Databases\baseball" 86-2-3
 - ▷ DatabaseManager.Model.FederationInfo 86-2-3
 - ☛ Host: "asus2" Path: "c:\databases\baseball" 2-2-2
 - ▷ VelocityDb.DatabaseLocation 2-2-2
 - ▷ 0 Transactions version: 1 pages: 4
 - ▷ 1 Schema version: 1 pages: 2
 - ▷ 2 DatabaseLocations version: 1 pages: 3
 - ▷ 4 License for mats.persson@gmail.com version: 12 pages: 4
 - ☛ 49 VelocityDbSchema.Samples.Baseball.AllStar version: 1 pages: 3
 - ▷ Page: 0 size: 8957 stored size: 8985 offset: 129300 compression: None noEncryption version: 1 objects: 6
 - ▷ Page: 1 size: 58 stored size: 86 offset: 129214 compression: None noEncryption version: 1 objects: 1 of type: VelocityDb.AutoPlaceholder
 - ☛ Page: 2 size: 129178 stored size: 129206 offset: 8 compression: None noEncryption version: 1 objects: 4475 of type: VelocityDbSchema.Samples.Baseball.AllStar 49-2-1
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-1
 - ☛ VelocityDbSchema.Samples.Baseball.AllStar 49-2-2
 - playerID : aaronha01
 - yearId : 1956
 - lgID : 1956
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-3
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-4
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-5
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-6
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-7
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-8
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-9
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-10
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-11
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-12
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-13
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-14
 - ▷ VelocityDbSchema.Samples.Baseball.AllStar 49-2-15

Validating Objects in your databases

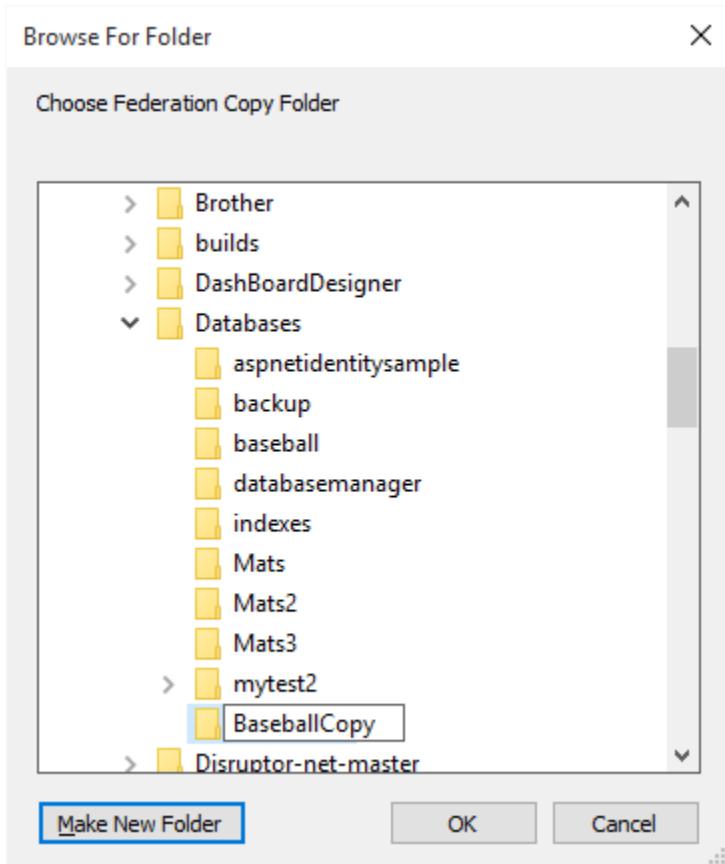
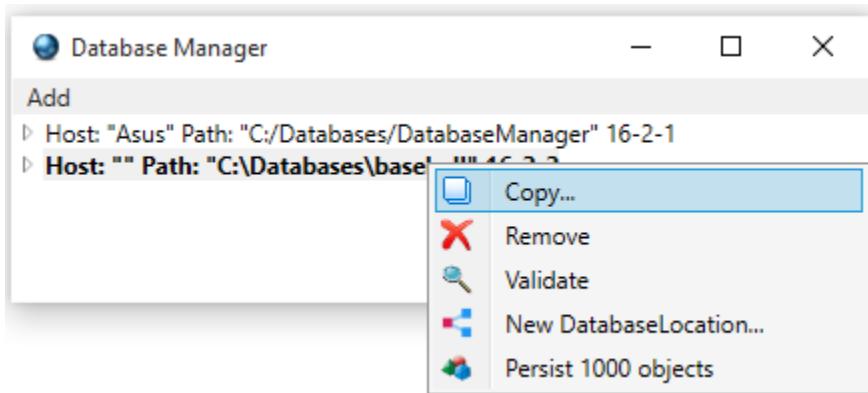
Run SessionBase.Validate() on your databases. It checks to make sure that all objects in your databases can be opened without errors.



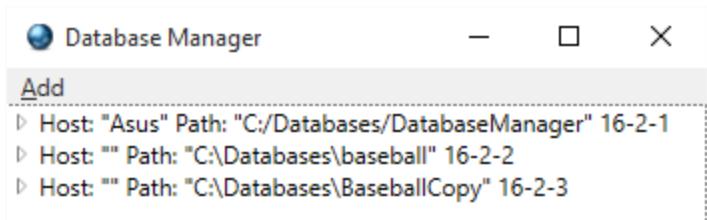
If all is good



Backing up (copy) all your database files

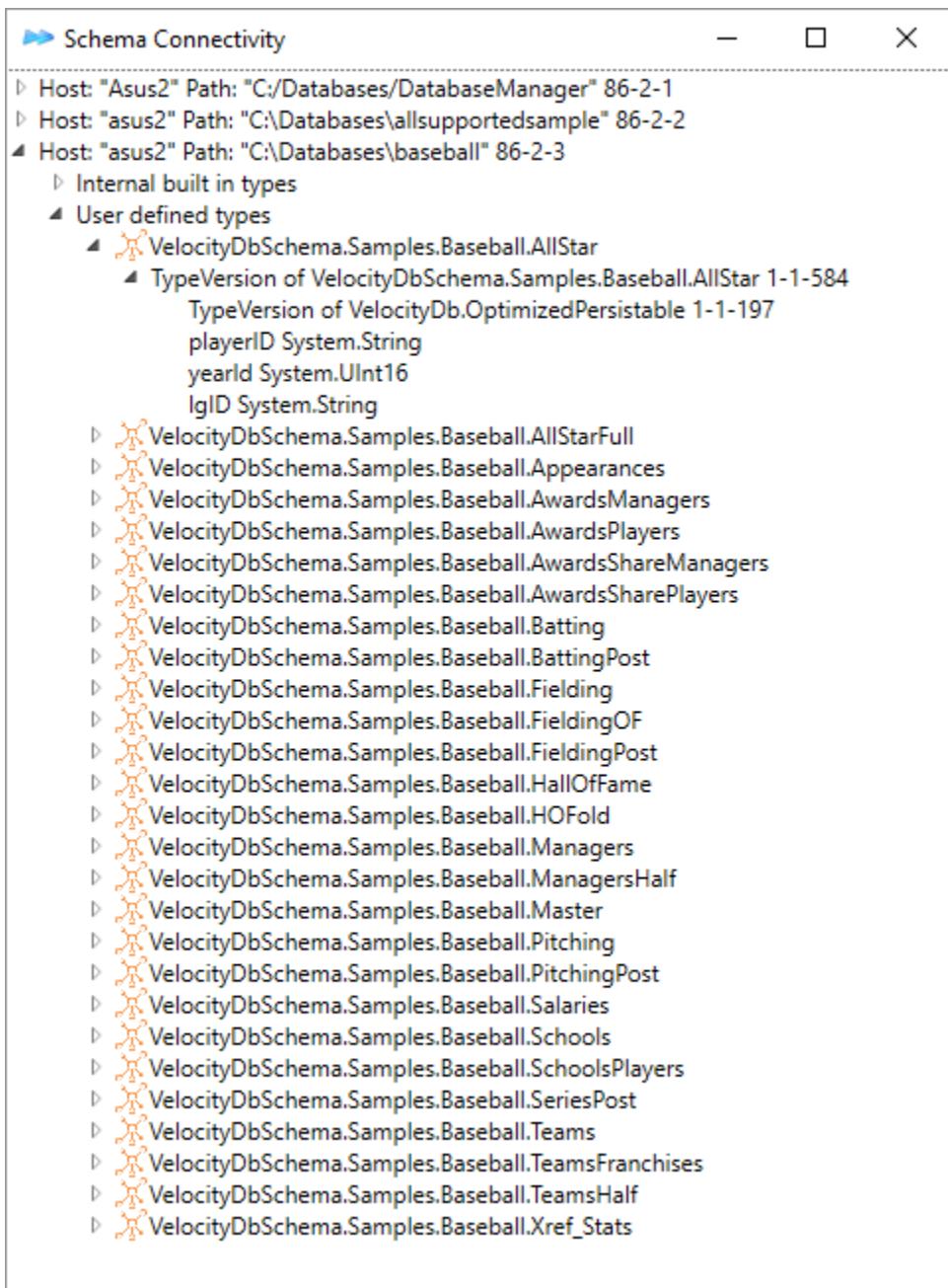


You now have a copy of the Baseball databases in a new folder. You can add this folder to the Database Administrator if you like.



Database Schema Connections

Click on Database Manager menu bar “Schema Connectivity”, a second window is opened.

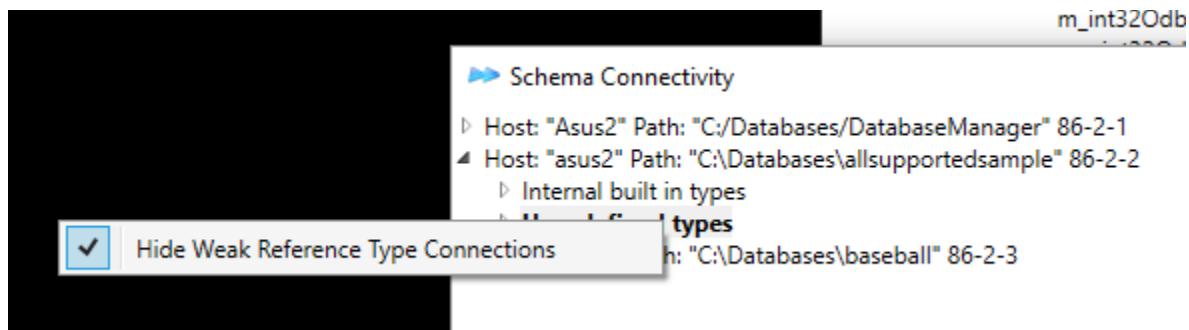


This window shows how the types of your persisted objects are connected via direct (strong) object references and via indirect (weak) references.

▶ Schema Connectivity

```
▷ m_stringOdbList VelocityDbList<System.String>
▷ m_petOdbList VelocityDbList<VelocityDbSchema.Samples.AllSupportedSample.Pet>
▷ petList2 System.Collections.ArrayList
    aSlot VelocityDbSchema.Samples.AllSupportedSample.AllSupported.Slot
▷ m_slots VelocityDbSchema.Samples.AllSupportedSample.AllSupported+Slot[]
▷ m_bTreePerson BTreeset<VelocityDbSchema.Samples.AllSupportedSample.Person>
▷ m_sortedSetPerson SortedSetAny<VelocityDbSchema.Samples.AllSupportedSample.Person>
◀ _weakRefToPerson WeakReferencedConnection<VelocityDbSchema.Samples.AllSupportedSample.Person>
    ▲ TypeVersion of VelocityDbSchema.Samples.AllSupportedSample.WeakReferencedConnection<VelocityDbSchema.Samples.AllSupportedSample.Person>
        TypeVersion of VelocityDb.OptimizedPersistable 1-1-197
        _objId System.UInt64
    ▲ ⚡ Weak Reference to VelocityDbSchema.Samples.AllSupportedSample.Person
        ▲ TypeVersion of VelocityDbSchema.Samples.AllSupportedSample.Person 1-1-626
            TypeVersion of VelocityDb.OptimizedPersistable 1-1-197
            m.firstName System.String
            m.lastName System.String
            m.age System.UInt16
            m.idNumber System.UInt64
        ▷ m_bestFriend VelocityDbSchema.Samples.AllSupportedSample.Person
            m_autoIncrement System.UInt64
        ▷ m_friends SortedSetAny<VelocityDbSchema.Samples.AllSupportedSample.Person>
    ▷ m_sortedMapByteToPerson SortedMap<System.Byte,VelocityDbSchema.Samples.AllSupportedSample.Person>
    ▷ personHashSet VelocityDbHashSet<VelocityDbSchema.Samples.AllSupportedSample.Person>
        m_nullableGuid Nullable<System.Guid>
    ▷ VelocityDbSchema.Samples.AllSupportedSample.AllSupported.Slot
    ▷ VelocityDbSchema.Samples.AllSupportedSample.Cat
    ▷ VelocityDbSchema.Samples.AllSupportedSample.PersistenceByInterfaceSnake
    ▷ VelocityDbSchema.Samples.AllSupportedSample.Person
    ▷ VelocityDbSchema.Samples.AllSupportedSample.Pet
    ▷ WeakReferencedConnection<VelocityDbSchema.Samples.AllSupportedSample.Person>
▷ Host: "asus2" Path: "C:\Databases\baseball" 86-2-3
```

It is possible to hide all weak references by right click on “Internal built in types or User defined types.

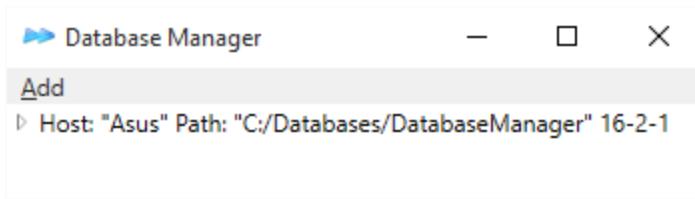


Backup & Restore using Database Manager

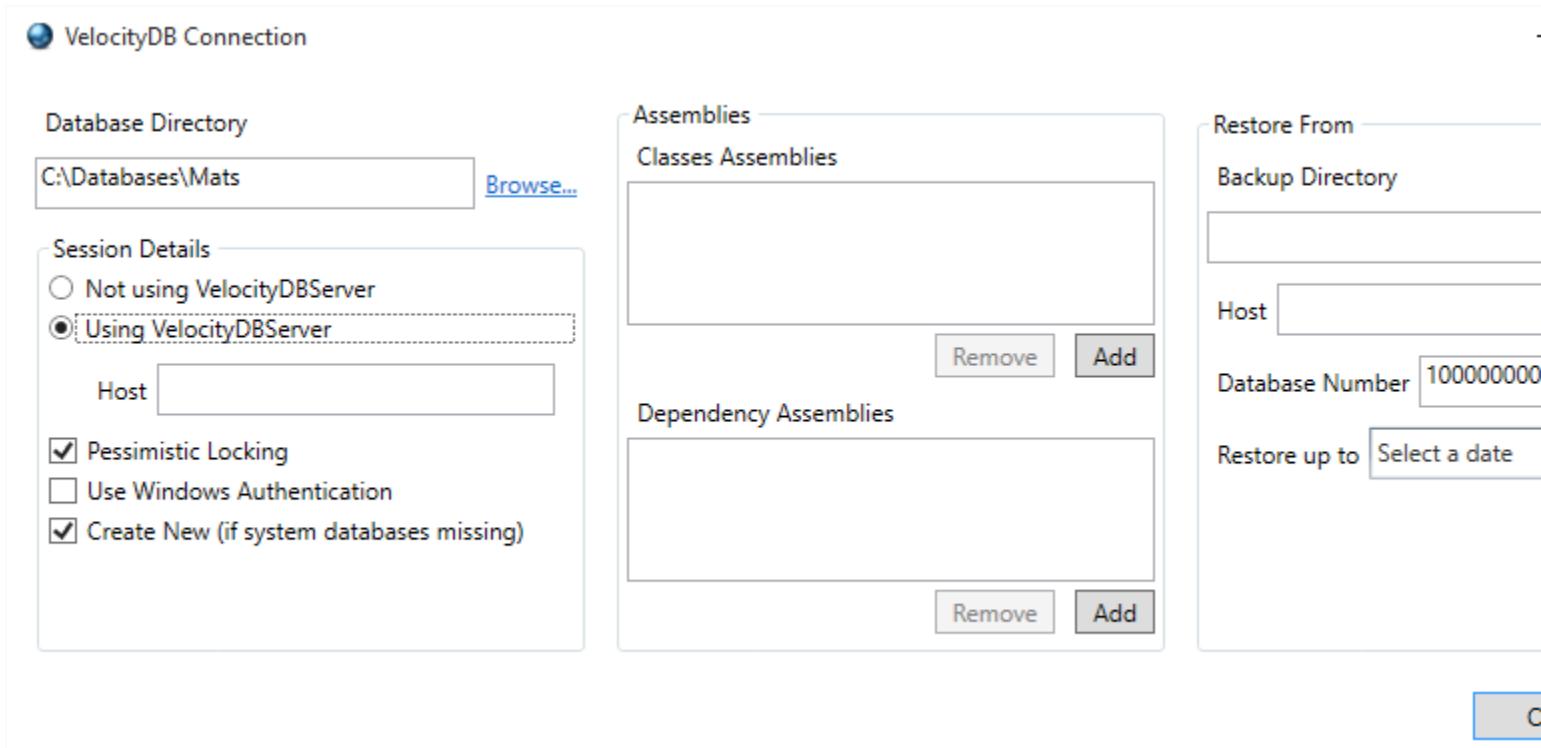
We will go through a simple scenario for this. Using a backup DatabaseLocation is not a one-time backup of your databases. When you create a backup DatabaseLocation a contiguous backup of all changes to the backed up DatabaseLocation starts and continues forever. The backing up is managed by the VelocityDBServer whenever you commit a change. All history of your changes is by default kept in the backup DatabaseLocation.

Create Database

Startup Database Manager



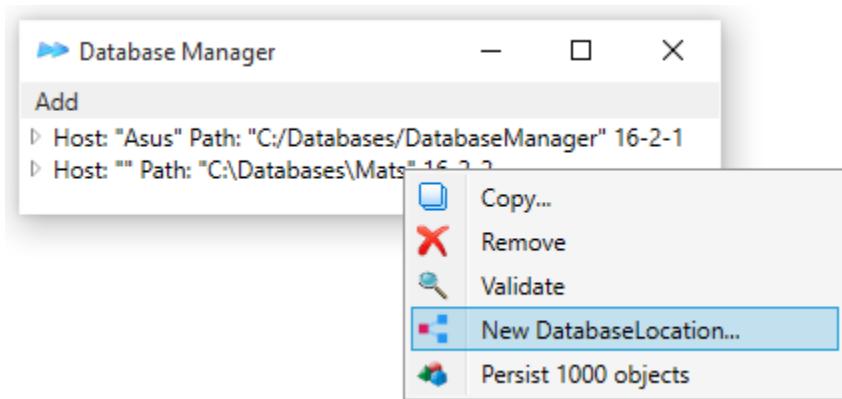
An initial admin database is created. This database contain info about all other databases you “Add” to the Database Manager. Now **click on the “Add” menu item.**



Fill in the requested data and **click on OK**

Create a backup Database Location

Right click on the newly created database and select “New DatabaseLocation...”



New DatabaseLocation

Directory
C:\Databases\BackupOfMats [Browse...](#)

Host

Backup Location

Is Backup Location

Backup of VelocityDb.DatabaseLocation 2-2-2

Compression None

Encryption

Type noEncryption

Key abcdefgh

Start Database Number 100000000

End Database Number 4294967295

OK Cancel

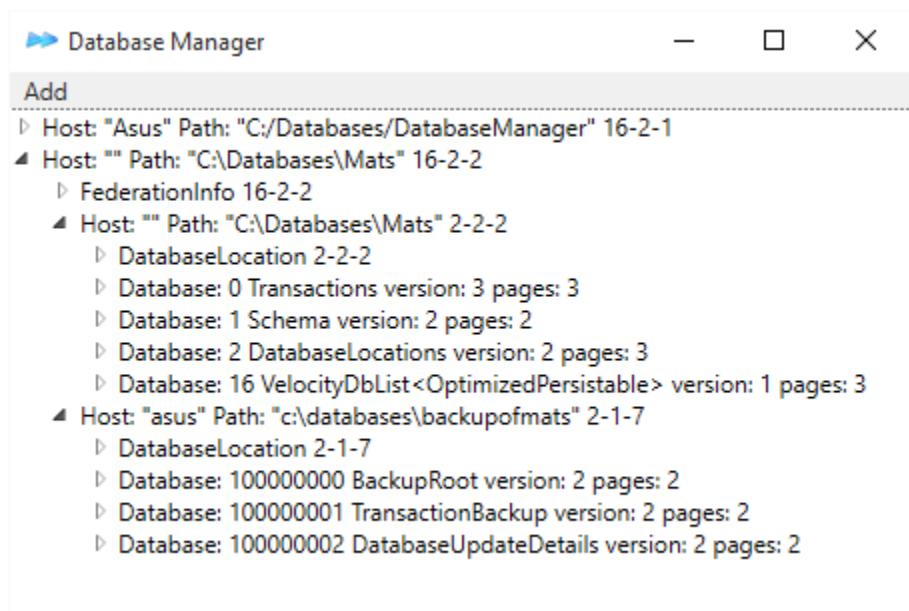
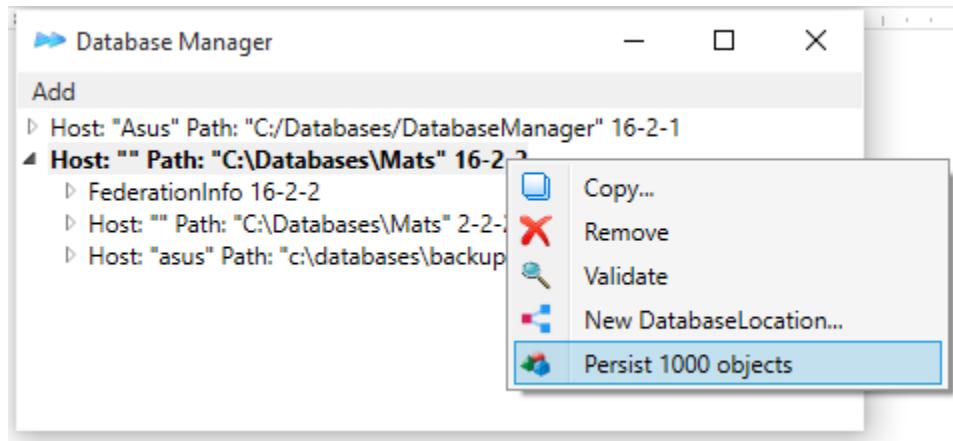
Fill in requested DatabaseLocation data like above and click on OK. Expand to see the new DatabaseLocation.

Database Manager

Add

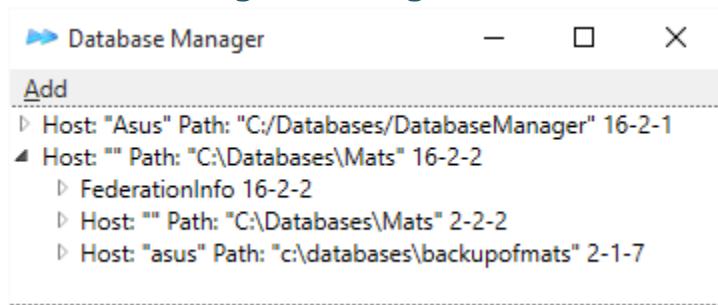
- ▷ Host: "Asus" Path: "C:/Databases/DatabaseManager" 16-2-1
- ◀ Host: "" Path: "C:\Databases\Mats" 16-2-2
 - ▷ FederationInfo 16-2-2
 - ▷ Host: "" Path: "C:\Databases\Mats" 2-2-2
 - ▷ Host: "asus" Path: "c:\databases\mats2" 2-1-7

Create some persistent objects

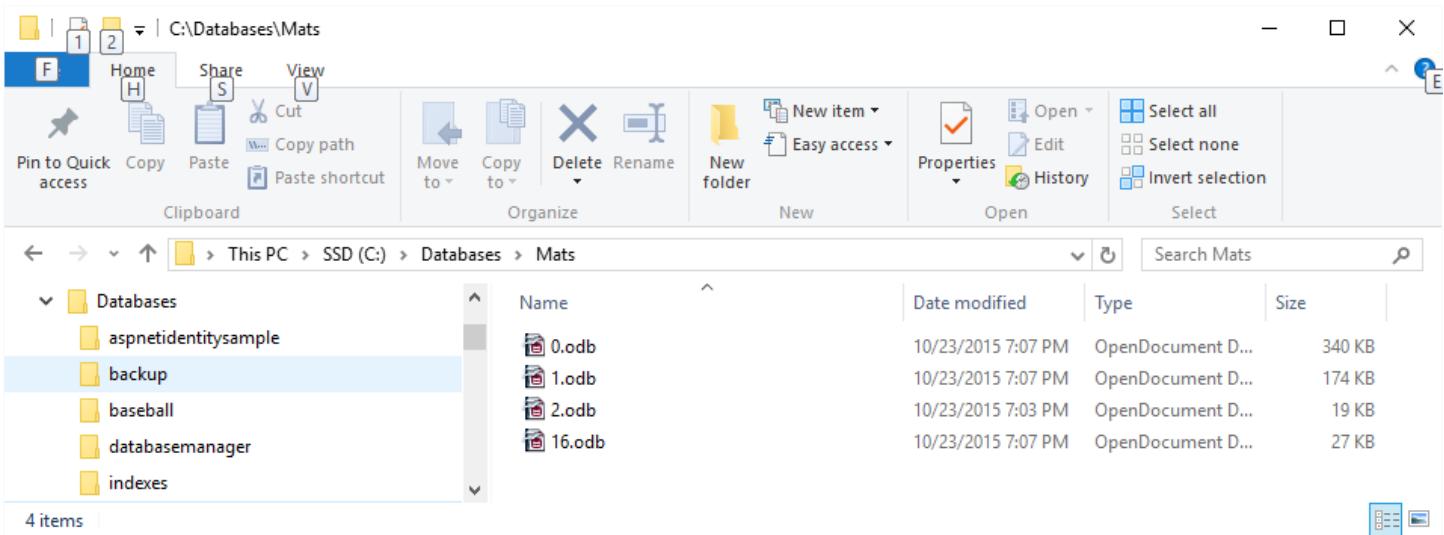


We now have some persistent objects and a backup of all data in original DatabaseLocation.

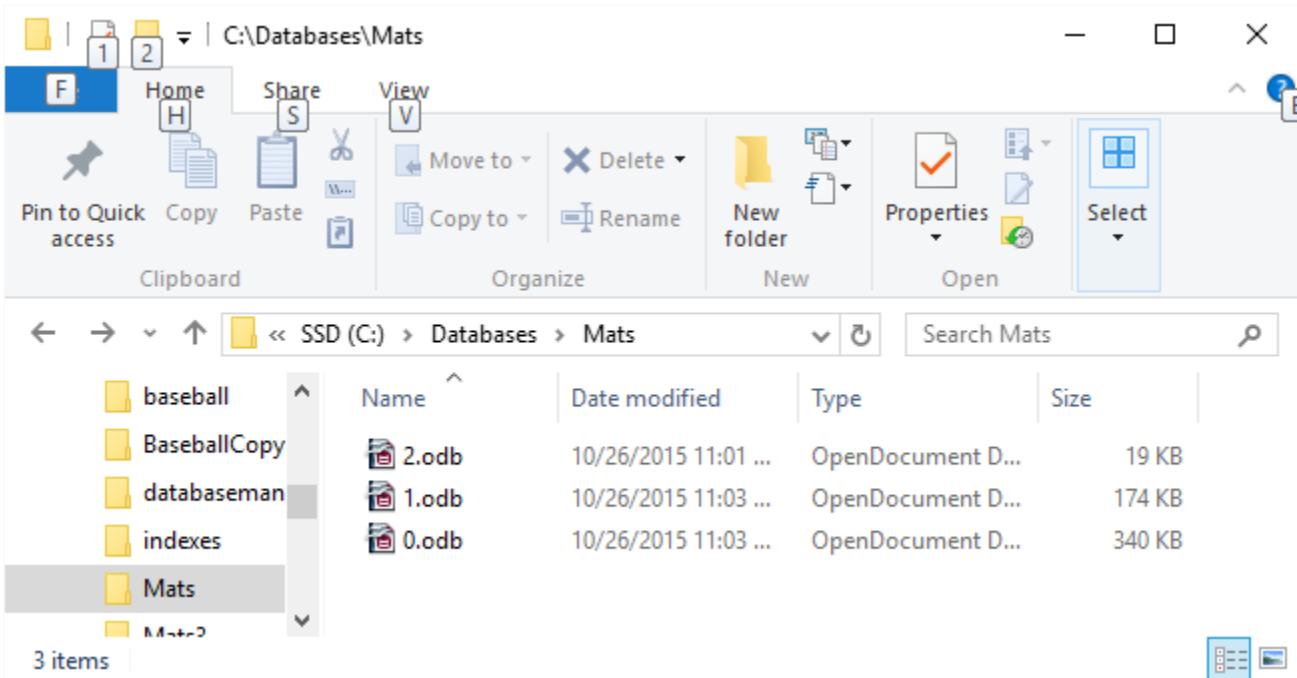
Simulate loosing files in original DatabaseLocation



Manually delete 16.odb in original DatabaseLocation

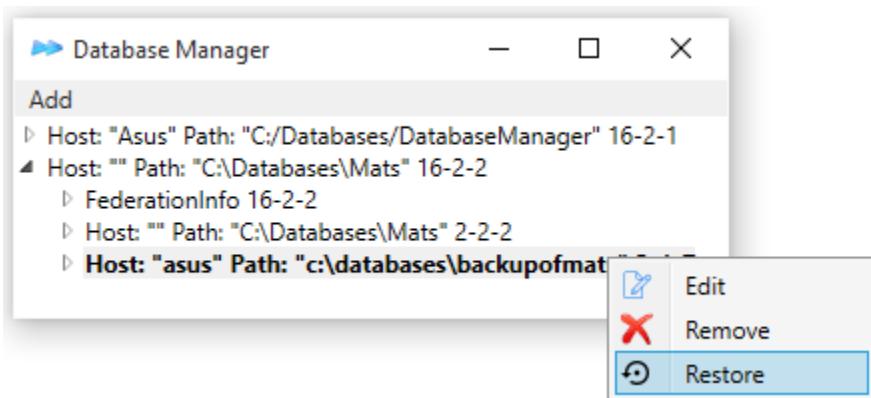


TO (by deleting using file Explorer)



Restore these databases from backup DatabaseLocation

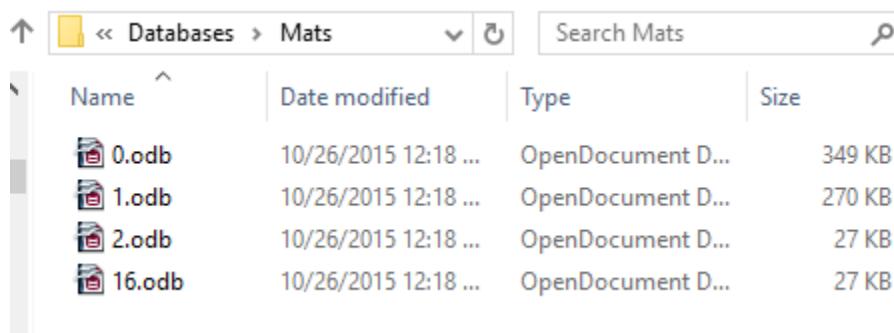
Be sure to expand before deleting the files!



Database Manager

Add
Host: "Asus" Path: "C:/Databases/DatabaseManager" 16-2-1
Host: "" Path: "C:\Databases\Mats" 16-2-2
FederationInfo 16-2-2
Host: "" Path: "C:\Databases\Mats" 2-2-2
DatabaseLocation 2-2-2
Database: 0 Transactions version: 5 pages: 3
Database: 1 Schema version: 4 pages: 2
Database: 2 DatabaseLocations version: 4 pages: 3
Database: 16 version: 1 pages: 3
Page: 0 size: 8916 stored size: 8944 compression: None noEncryption version: 1 objects: 6
Page: 1 size: 58 stored size: 86 compression: None noEncryption version: 1 objects: 1 of type: VelocityDb.AutoPlacement
Page: 2 size: 18000 stored size: 18028 compression: None noEncryption version: 1 objects: 1000 of type: VelocityDbList<VelocityDb.
Host: "asus" Path: "c:\databases\backupofmats" 2-1-7
DatabaseLocation 2-1-7
Database: 100000000 BackupRoot version: 4 pages: 2
Database: 100000001 TransactionBackup version: 2 pages: 2
Database: 100000002 DatabaseUpdateDetails version: 2 pages: 2

Your database file is now restored in your original DatabaseLocation.



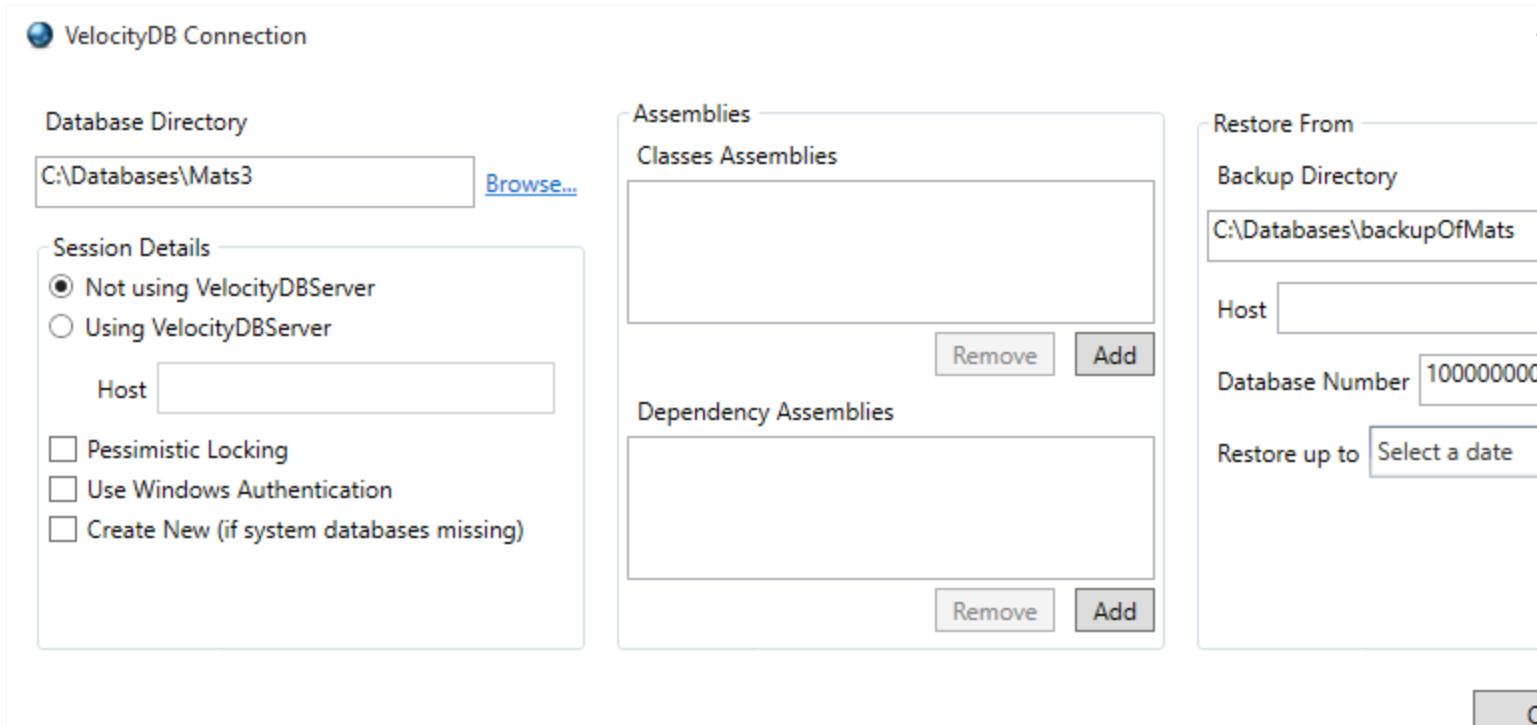
The screenshot shows a Windows-style application window titled "Database Manager". At the top, there's a toolbar with icons for back, forward, search, and refresh. Below the toolbar, the title bar says "Databases > Mats". A search bar labeled "Search Mats" is also present. The main area is a table with the following data:

Name	Date modified	Type	Size
0.odb	10/26/2015 12:18 ...	OpenDocument D...	349 KB
1.odb	10/26/2015 12:18 ...	OpenDocument D...	270 KB
2.odb	10/26/2015 12:18 ...	OpenDocument D...	27 KB
16.odb	10/26/2015 12:18 ...	OpenDocument D...	27 KB

Restore a backup DatabaseLocation to a brand new directory

A backup DatabaseLocation can be used to create a new set of databases on a new host and directory. Given the backup made in prior section, we will show how to use it to create a new DatabaseLocation in a new directory.

Startup DatabaseManager and click on “Add”



Fill in data like above. The above “Database Number” correspond to the first database in the backup DatabaseLocation, by default we set it to 100000000. Click OK.

You now have a brand new DatabaseLocation with all the data backed up in the backup DatabaseLocation.

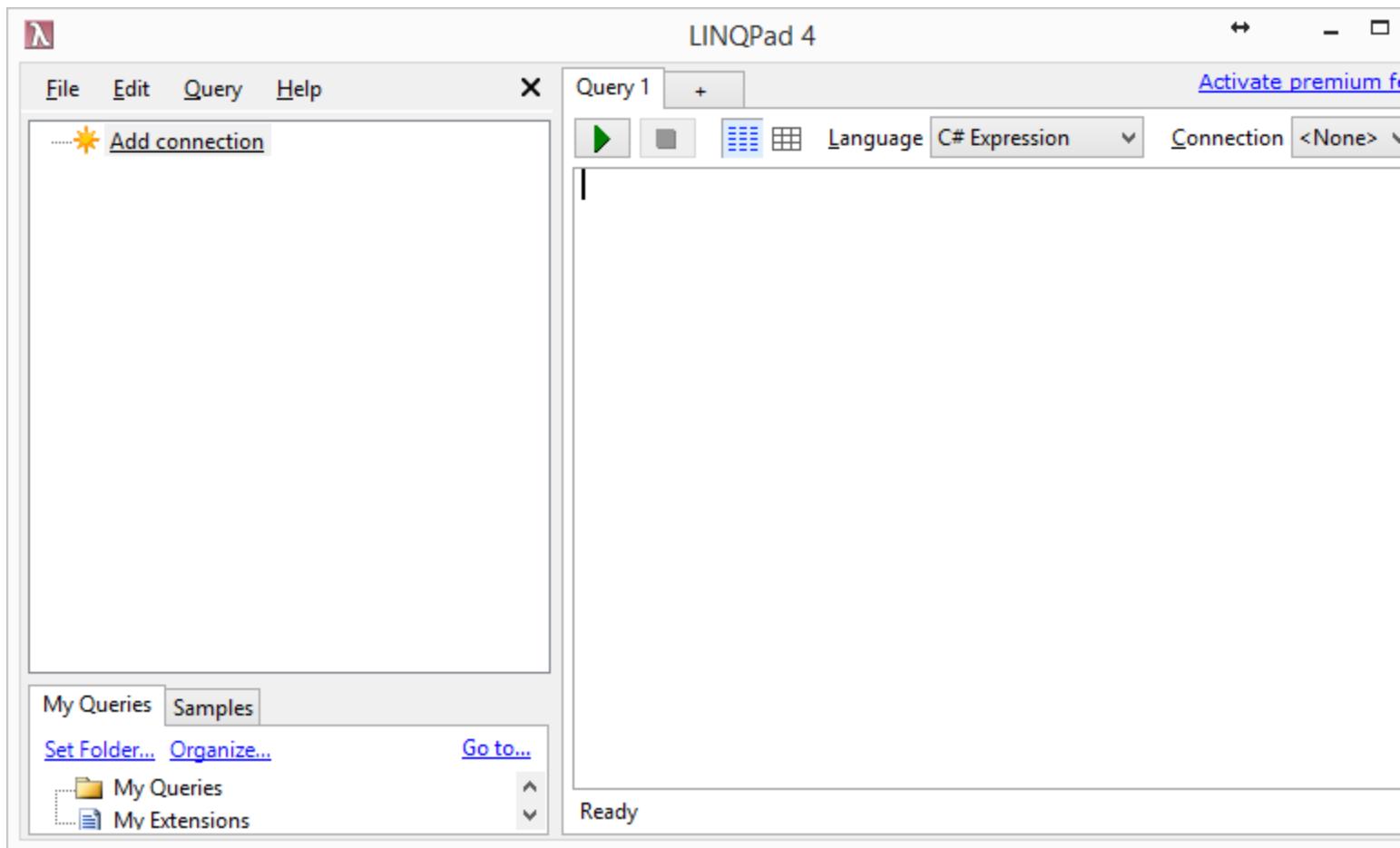
Database Manager

Add

- ▷ Host: "Asus" Path: "C:/Databases/DatabaseManager" 16-2-1
- ▷ Host: "" Path: "C:\Databases\Mats" 16-2-2
- ◀ Host: "" Path: "C:\Databases\Mats3" 16-2-3
 - ◀ FederationInfo 16-2-3
 - m_name : null
 - m_hostName :
 - m_systemDbsPath : C:\Databases\Mats3
 - m_portNumber : 7031
 - m_windowsAuthentication : False
 - m_usesServerClient : False
 - m_usePessimisticLocking : False
 - m_validated List<DateTime> size: 0
 - ▷ m_typesAssemblies System.String[] size: 0
 - ▷ m_typesDependencyAssemblies System.String[] size: 0
 - m_federationCopies List<FederationCopyInfo> size: 0
 - ◀ Host: "asus" Path: "c:\databases\mats3" 2-2-2
 - ▷ DatabaseLocation 2-2-2
 - ▷ Database: 0 Transactions version: 1 pages: 3
 - ▷ Database: 1 Schema version: 1 pages: 2
 - ▷ Database: 2 DatabaseLocations version: 1 pages: 3
 - ◀ Database: 16 VelocityDbList<OptimizedPersistable> version: 1 pages: 3
 - ▷ Page: 0 size: 8952 stored size: 8980 compression: None noEncryption version: 1 objects: 6
 - ▷ Page: 1 size: 58 stored size: 86 compression: None noEncryption version: 1 objects: 1 of type: VelocityDb.AutoPlacer
 - ▷ Page: 2 size: 18000 stored size: 18028 compression: None noEncryption version: 1 objects: 1000 of type: VelocityDb

Using LINQPad to make VelocityDB LINQ queries/browsing

Here is how to set it up. Start by downloading and installing LINQPad from <http://www.linqpad.net/>. Start it. It should look like this:



Click on “Add connection”, takes you to this:

Choose Data Context

X

Build data context automatically

LINQPad Driver	Version	Author
Default (LINQ to SQL)	(built-in)	(built in)
WCF Data Services 5.5 (OData 3)	(built-in)	(built in)
Microsoft DataMarket Service	(built-in)	(built in)

Delete Driver

Use a typed data context from your own assembly

LINQPad Driver	Version	Author
LINQ to SQL	(built-in)	(built in)
Entity Framework (DbContext)	(built-in)	(built in)
Entity Framework (ObjectContext)	(built-in)	(built in)

Delete Driver

[View more drivers...](#)

[Next >](#)

[Cancel](#)

Click on “View more drivers...”, takes you to this:



Choose from the featured drivers:

LINQPad Supplementary Data Context Drivers

Blocked by a proxy or firewall? [Click here](#) to download these drivers from a web browser.

IQ Driver - for MySQL, SQLite, Oracle

by Joe Albahari, Matt Warren, WiCKY Hu Version 2.1.1

▼ [Download & Enable Driver](#) (download again to update the driver)

This LINQPad driver uses [Matt Warren's IQueryable toolkit](#) and supports MySQL, SQLite and Oracle. Everything you need is included and you can be querying within seconds: no extra drivers or providers are required (you don't even have to install the Oracle client!) Querying functionality is (almost) on par with LINQ to SQL, and updates are supported (although not through associations). Plain SQL queries are supported, too. This driver does not alter your machine configuration in any way (nor does it install anything into the GAC).

Matt Warren's IQueryable Toolkit © Microsoft Corporation (used under [Ms-PL license](#)). Oracle IQ Provider by [WiCKY Hu \(BSD License\)](#). ADO.NET providers for MySQL and Oracle by [DevArt](#).



Microsoft StreamInsight Driver

By downloading the Microsoft StreamInsight Driver for Linqpad you agree to the terms of the [Microsoft Software License Terms](#).

▼ [Download Driver for StreamInsight 2.1](#) Version 0.9.3 (download again to update)

▼ [Download Driver for StreamInsight 2.0](#) Version 0.9.2 (download again to update)

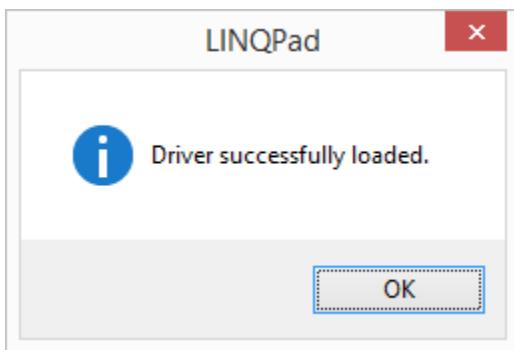
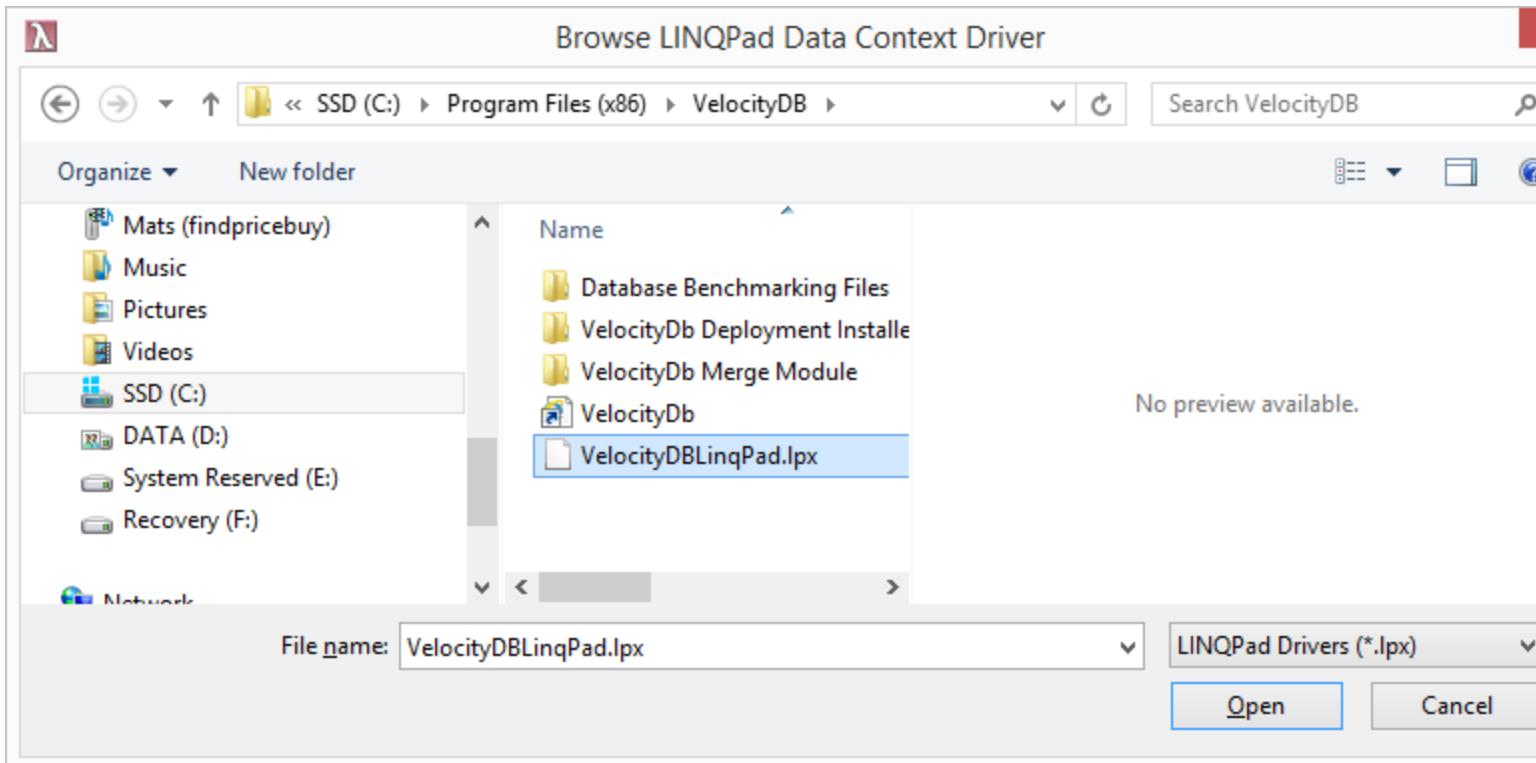
▼ [Download Driver for StreamInsight 1.1 / 1.2](#) (download again to update)

Or, browse to a .LPX file:

[Browse...](#)

Close

Click on "Browse...", select the file VelocityDBLinqPad.lpx from your VelocityDB installation directory



Then select the VelocityDB data context and click on "Next >"

X

Choose Data Context

Build data context automatically

LINQPad Driver	Version	Author
Default (LINQ to SQL)	(built-in)	(built in)
WCF Data Services 5.5 (OData 3)	(built-in)	(built in)
Microsoft DataMarket Service	(built-in)	(built in)
VelocityDB	1.0.0.0	Laércio Asano

[Delete Driver](#)

Use a typed data context from your own assembly

LINQPad Driver	Version	Author
LINQ to SQL	(built-in)	(built in)
Entity Framework (DbContext)	(built-in)	(built in)
Entity Framework (ObjectContext)	(built-in)	(built in)

[Delete Driver](#)

[View more drivers...](#)

[Next >](#) [Cancel](#)

You should now see:

VelocityDB Connection

DB Directory

Browse...

Session Details

- No Server
- No Server Shared
- Server Client

Host

Pessimistic Locking

Assemblies

Classes Assemblies

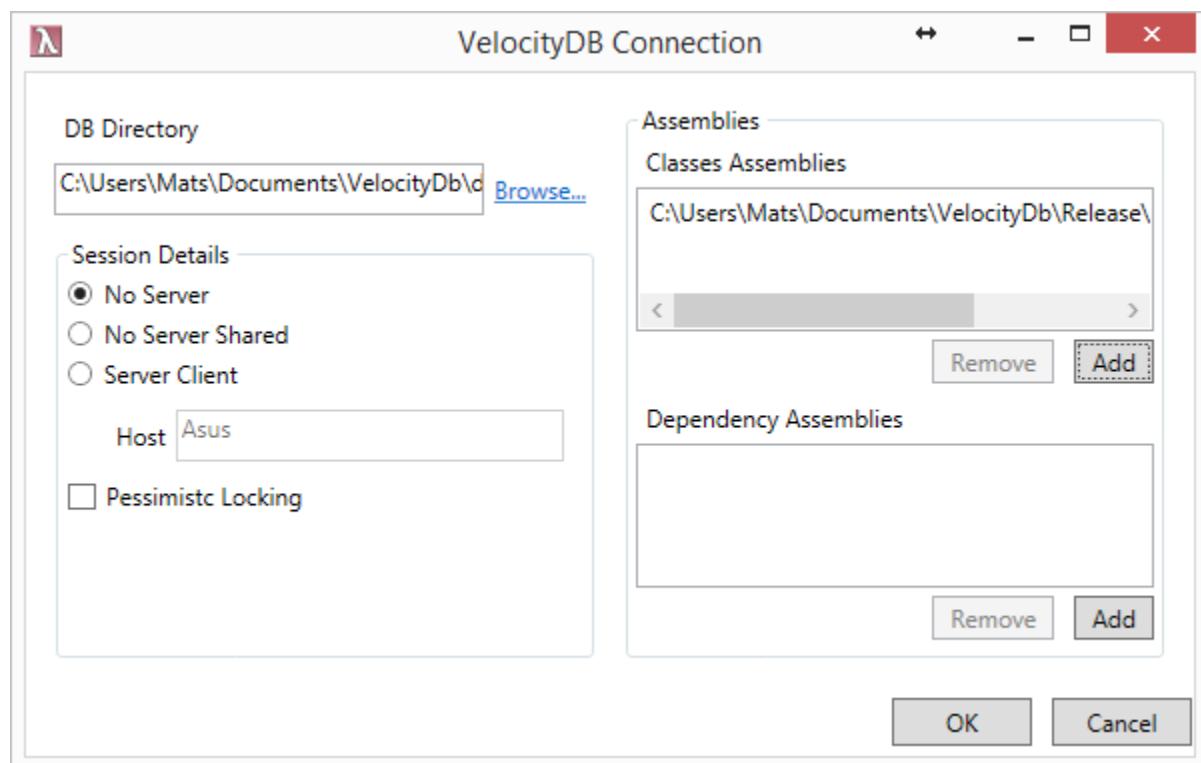
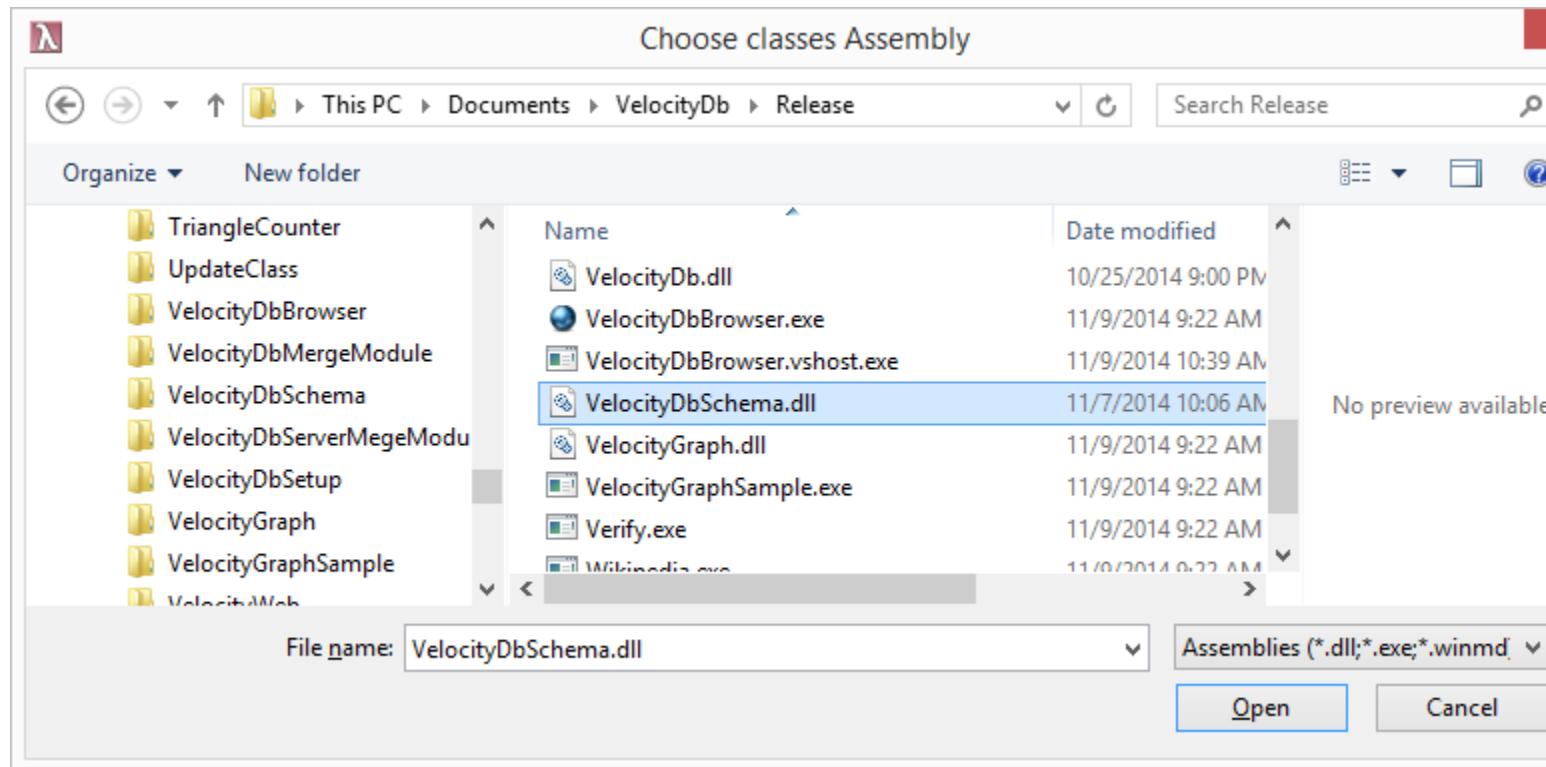
[Remove](#) [Add](#)

Dependency Assemblies

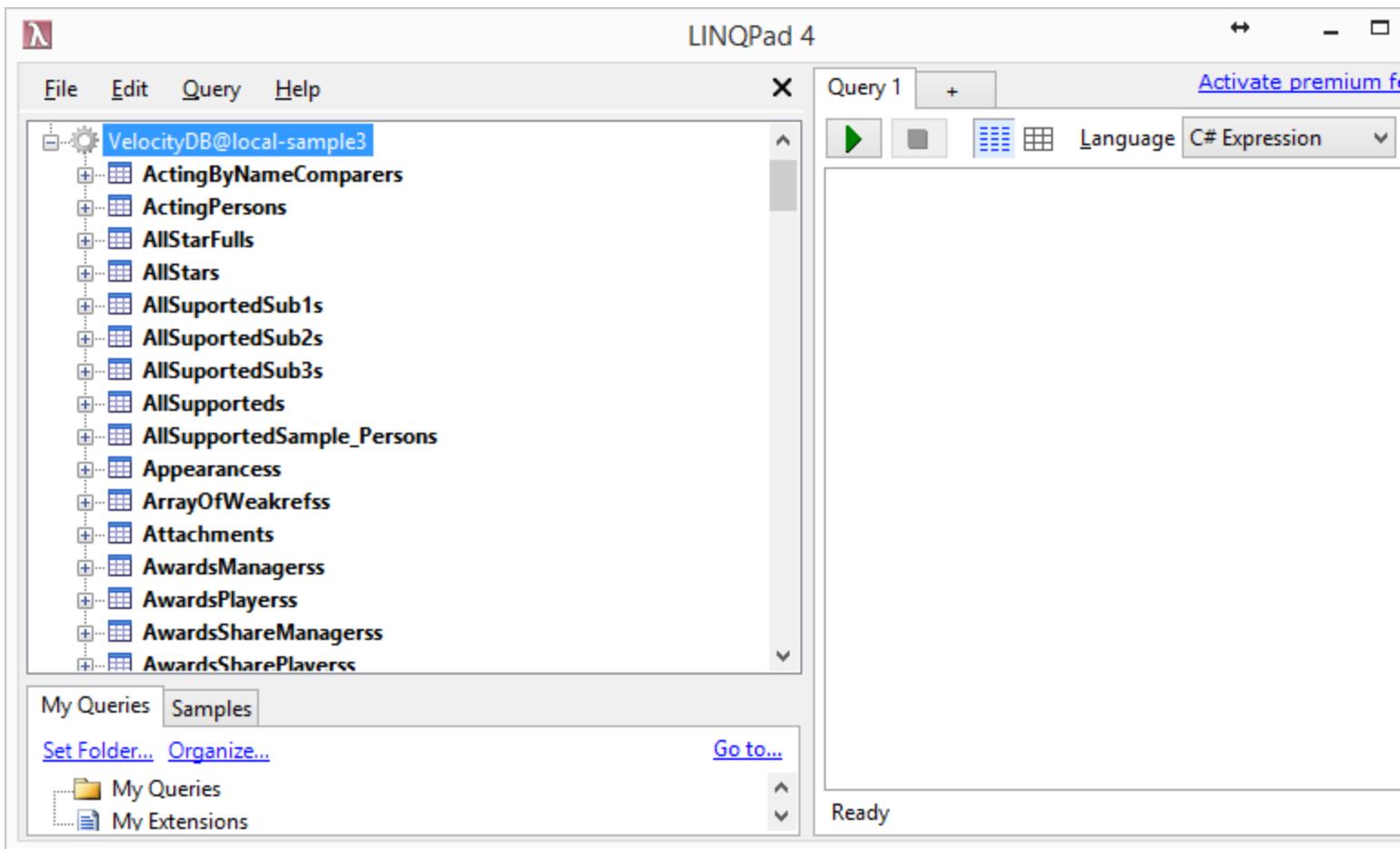
[Remove](#) [Add](#)

[OK](#) [Cancel](#)

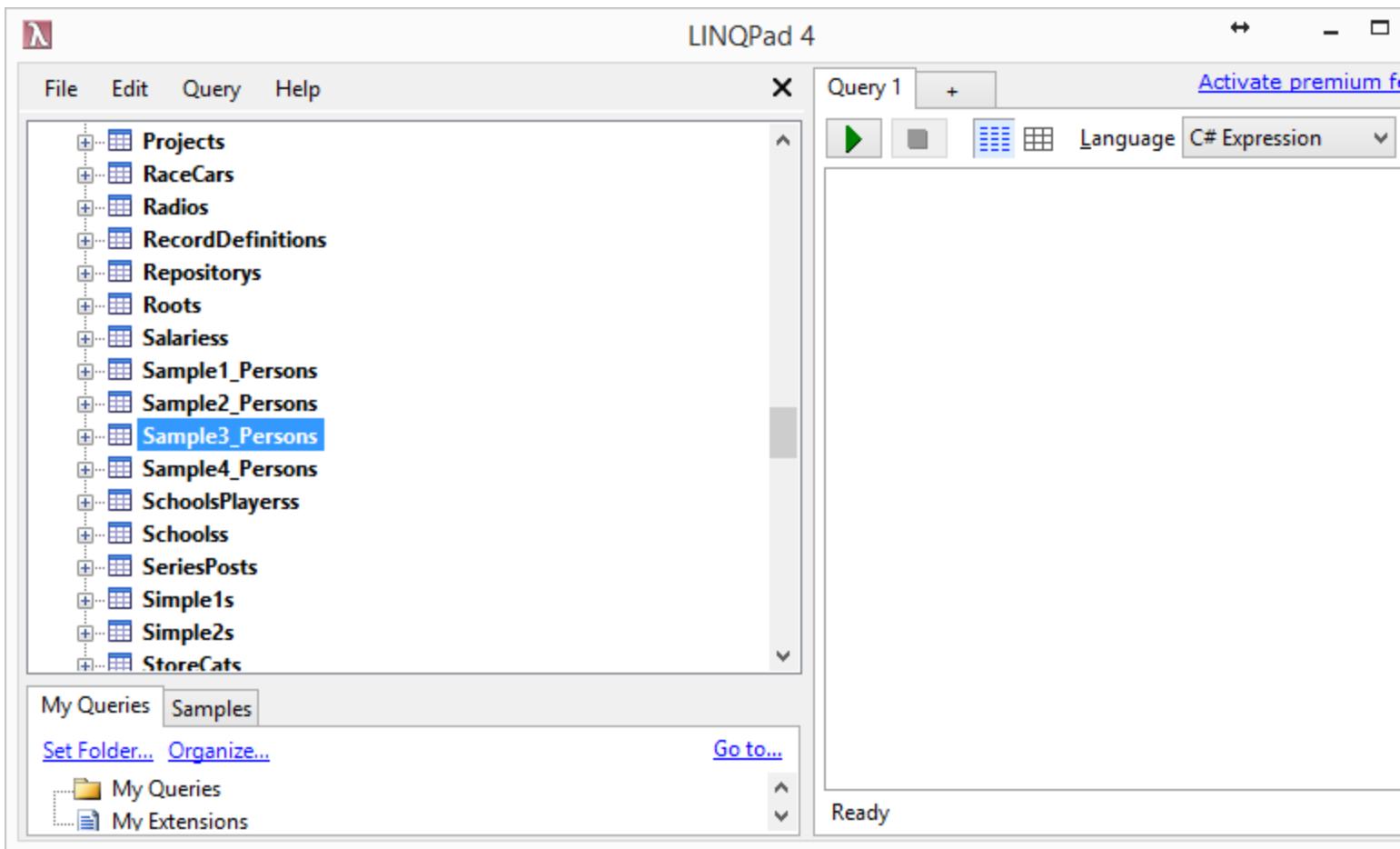
Choose DB Directory and Assemblies. Choose the assembly where your persisted classes are defined. If these are defined in an .exe file you may have to move them to a library project instead and reference it from your .exe.



Then press "OK", should take you to this (in this case using Sample3 database directory from VelocityDB.sln samples)



Scroll down to “Sample3_Persons”, select and right click with mouse, choose “Sample3_Persons.Take(100)”



Result should now show as:

File Edit Query Help

Projects RaceCars Radios RecordDefinitions Repositorys Roots Salariess Sample1_Persons Sample2_Persons Sample3_Persons Sample4_Persons SchoolsPlayersss Schools SeriesPosts Simple1s Simple2s StoreCats StoreLists StoreStructs StringRecord2s StringRecords StringTests SubTasks Tables TeamsFranchisess TeamsHalfs Teamss TestCases TestClasss TestRecords TestRecs TickOptimizeds Ticks Trucks

Sample3_Persons.Take (100)

Results SQL IL

BestFriend

Person	
BestFriend	Person
FirstName	Robin
Friends	List<Person> (1 item)

Person

Person	
BestFriend	Person
FirstName	Bill
Friends	List<Person> (1 item)

BestFriend

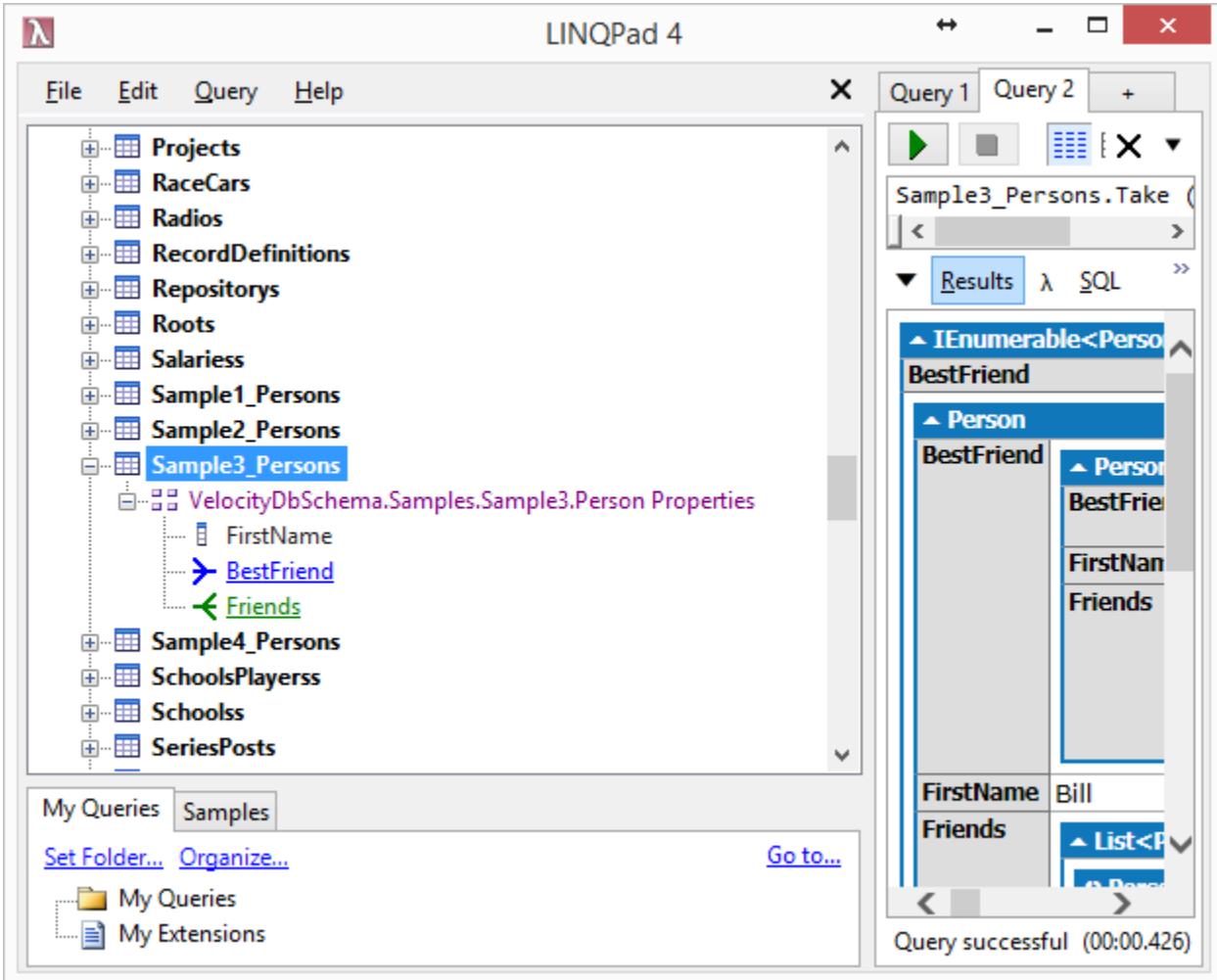
Person	
BestFriend	Person
FirstName	Robin
Friends	List<Person> (1 item)

Person

Person	
BestFriend	Person
FirstName	Bill
Friends	List<Person> (1 item)

Query successful (00:00:426)

Issues with current LINQPad driver



Proper class names are not displayed, above “Sample3_Persons” should really be ‘VelocityDbSchema.Samples.Sample3.Person’ as shown when you expand to see properties. Also objects and classes of template classes are not included. We’ll try to resolve these issues as soon as possible but it’s tricky due to using properties to expose each class and property names cannot have the characters “.<>” in them.

Controlling the in memory page and object caching

Be default VelocityDB tries to cache database pages whenever there is enough available RAM memory. You can control how much enough RAM memory is by API on the `DataCache` object that is accessed from a session object by the property `ClientCache`. You can also completely turn off page caching by specifying this as one of the optional parameters when creating a session. Object caching is also supported, see how to [here](#).

Verifying all objects and references

The Verify.exe application provided in the sample solution can be used to verify your data. Run Verify.exe and specify as command line parameter the directory where your databases are located. Verify.exe walks through all objects and opens all their references and it iterates though all enumeration types such as BTreeset and other collections. An exception will be thrown if a failure is found. You can also verify all objects by API using `SessionBase.Verify()`.

Scalability

A single session can manage uncompressed data at a maximum size of a half trillion terabytes (half a yottabyte). To reach that maximum size you need 4 billion databases (.odb files) with 65 thousand pages in each and each page size near 2 GB. An application can simultaneously use multiple sessions so total data size is unlimited.

- 2 GB is maximum size for a page. Limit is due to .Net [2GB limitation](#) of byte[].

Given this 2GB size limitation, it is not possible to persist objects such as [Dictionary<TKey, TValue>](#) that are larger than 2 GB. However, our BTree and BTreeMap collections can be used because they are composite objects where each object is smaller than 2GB no matter how large the total size of the collection (or map).

Database backup and restore

Database backup is an option on each [DatabaseLocation](#), you can request that all databases of a specified [DatabaseLocation](#) are backed up to a backup [DatabaseLocation](#). This API is currently only supported with [ServerClientSession](#).

Backup

The following code creates a backup [DatabaseLocation](#) for the default [DatabaseLocation](#) (the one containing the system database 0, 1, 2, and 4)

```
using (ServerClientSession session = new ServerClientSession(systemDir, Dns.GetHostName()))  
{  
    const bool isBackupLocation = true;  
    session.BeginUpdate();  
    DatabaseLocation backupLocation = new DatabaseLocation(Dns.GetHostName(),  
        "c:/NUnitTestDbsBackup",  
        (uint)Math.Pow(2, 24),  
        UInt32.MaxValue,  
        session,  
        false,  
        PageInfo.encryptedKind.noEncryption,  
        isBackupLocation,  
        session.DatabaseLocations.Default());  
    session.NewLocation(backupLocation);  
    session.Commit();  
}
```

From now on, every time a default [DatabaseLocation](#) database is created/updated, it will be backed up to the backup [DatabaseLocation](#).

Restore

The following code restores the default [DatabaseLocation](#) from its backup.

```
using (SessionNoServer session = new SessionNoServer(systemDir))  
{  
    session.BeginUpdate();  
    DatabaseLocation backupLocation = new DatabaseLocation(Dns.GetHostName(), "c:/NUnitTestDbsBackup",  
        (uint)Math.Pow(2, 24), UInt32.MaxValue, session,  
        false, PageInfo.encryptedKind.noEncryption, true, session.DatabaseLocations.Default())  
    session.RestoreFrom(backupLocation, DateTime.Now);  
    session.Commit(false, true);  
}
```

CopyAllDatabasesTo

A fast and easy way to backup your databases is to use [SessionBase.CopyAllDatabasesTo](#), as in

```

using (ServerClientSession session = new ServerClientSession(systemDir))
{
    session.CopyAllDatabasesTo(copyDbsDir);
}

using (SessionNoServer session = new SessionNoServer(copyDbsDir))
{
    session.BeginRead();
    session.Verify();
    session.Commit();
}

```

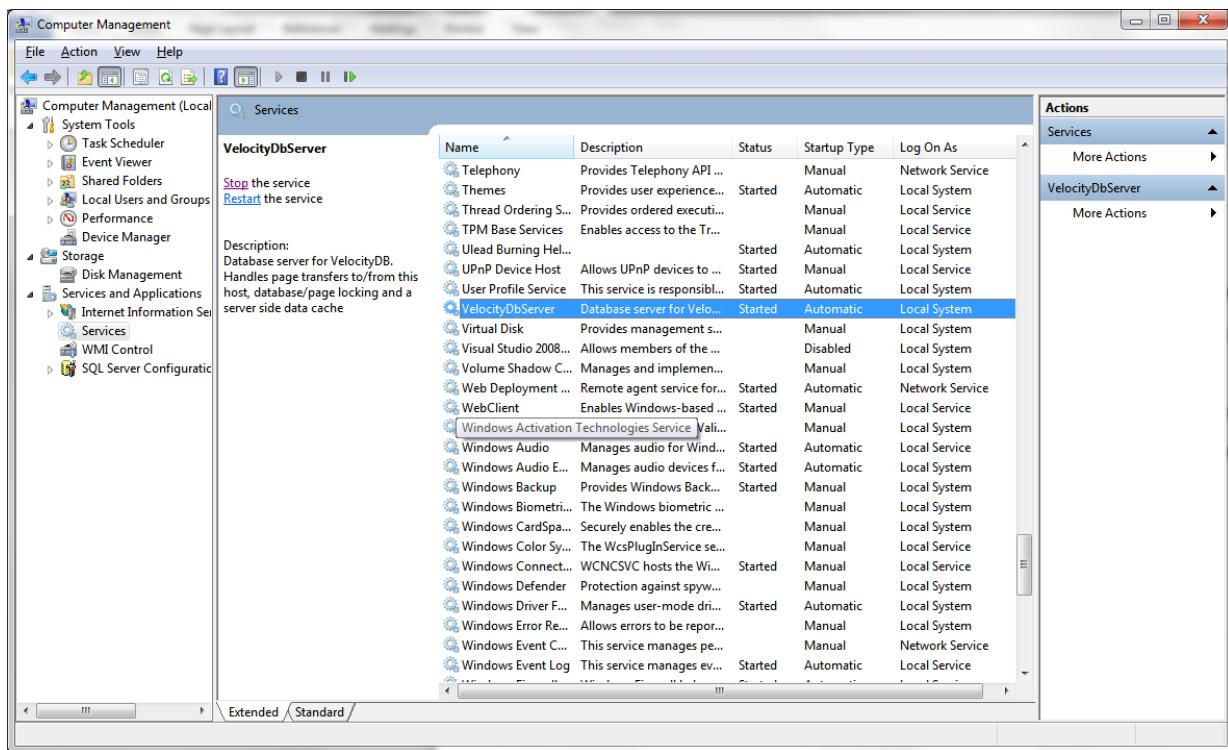
ExportToCSV and ImportFromCsv

SessionBase provides a to and from CSV file option. The CSV export files contains one csv file for each Type stored in the databases.

VelocityDbServer.exe

This is a server process that manages data transfer between client and server hosts. It also handles the page/database locking and manages a shared cache. The use of this server process is optional but is required in order to distribute databases and the server is also required when page level locking is requested.

VelocityDbServer.exe is installed as a service unless you did the install choosing VelocityDbNoServer.exe. You can configure it using the Windows Computer Management



If you don't want it running as a service, you can remove it after stopping by the command: sc delete VelocityDbServer. Or simply change the "Automatic" start to "Manual" start.

The server can be started from command line: VelocityDbServer true 10

Substitute "10" with how many worker threads you want it to use for each system database directory (one containing 0.odb, 1.odb, 2.odb 4.odb) this server is serving. The process runs as background process. A non-service VelocityDbServer is stopped by using the Task manager.

In order to distribute databases to multiple hosts, you need to install VelocityDb on each host where you want to place databases.

The VelocityDbServer is communicating on tcp/ip port number: **7031**. This server can only handle .NET clients, not .net core clients. .net core clients use port 7032 instead and the server is [VelocityDbCoreServer](#). Both these servers are installed as services by the installer.

Make sure that your Firewall lets VelocityDbServer listen/talk to other hosts with VelocityDbServer running on them.

If you are experiencing issues with the VelocityDbServer, it may help to look at the VelocityDBServerLog in the Event log, as in

Changing the default SessionBase. BaseDatabasePath in a VelocityDbServer

Edit VelocityDbServer.exe.config (in Program Folder (x86)\VelocityDB)

```
<?xml version="1.0"?>
<configuration>
<startup><supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.0"/></startup>
<appSettings>
  <add key="BaseDatabasePath" value="c:\Databases"/>
  <add key="DoWindowsAuthentication" value="false"/>
  <add key="NumberOfWorkerThreads" value="10"/>
</appSettings>
</configuration>
```

Option to log all activity in VelocityDBServer

You can turn on a log of all activity in a VelocityDBServer by setting the file path of ServerActivityLogFile. Set to empty string if you don't want it.

```
<?xml version="1.0"?>
<configuration>
<startup><supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.0"/></startup>
<appSettings>
  <add key="BaseDatabasePath" value="c:/Databases"/>
  <add key="DoWindowsAuthentication" value="false"/>
  <add key="NumberOfWorkerThreads" value="10"/>
  <add key="ServerActivityLogFile" value="d:/serverLog.txt"/>
  <add key="TcpIpPortNumber" value="7031"/>
  <add key="MaximumMemoryUse" value="10000000000"/>
</appSettings>
</configuration><?xml version="1.0"?>
```

Changing the tcp/ip port number used when communication with a VelocityDBServer

By default, VelocityDbServer is communicating on tcp/ip port number: **7031**.

If you need to use a different port number, set `SessionBase.s_serverTcpIpPortNumber` and update VelocityDBServer.exe.config (in VelocityDB installation directory) of each VelocityDB installation where you want this change.

Enabling Windows Authentication

By default Windows Authentication is now disabled when connecting to a VelocityDBServer. It is disabled by default due to a slight performance cost when connecting to a server and also due to issues with making it work with Windows 8.1 clients.

Edit VelocityDbServer.exe.config (in Program Folder (x86)\VelocityDB)

```
<?xml version="1.0"?>
<configuration>
<startup><supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.0"/></startup>
<appSettings>
  <add key="BaseDatabasePath" value="c:\Databases"/>
  <add key="DoWindowsAuthentication" value="false"/>
  <add key="NumberOfWorkerThreads" value="10"/>
</appSettings>
</configuration>
```

In each of your clients set

```
SessionBase.DoWindowsAuthentication = true;
```

VelocityDBCoreServer with http REST Api

Preview release of VelocityDB http API via Asp.Net Core 3.1 server combined with regular VelocityDBServer functions all in one. Connect as: localhost:7033/active, this server uses port 7032 for VelocityDBServer functions. .NET Core have a mismatch with regular .NET in type names. Specifically noticed so far is mscorelib -> [System.Private.CoreLib](#). To test using this server instead of regular .NET one, build a .netcore application using ClientServerSession.

API will eventually almost everything imaginable that can be done: retrieving object by id, creating new objects, deleting objects, updating objects, authentication...

What we probably will not support:

- Creating new classes or other Type instances. DLLs containing the application classes will have to be provided to server, so it can work with such object instances.

Let us know what you would like to see in this https REST API? We really appreciate all input. The source code of the VelocityDBCoreServer will soon be included in our sample solution and on GitHub.

Active connections to VelocityDBCoreServer

← → ⌂ ⓘ localhost:7033/active

```
[ "c:\\databases\\sample1"]
```

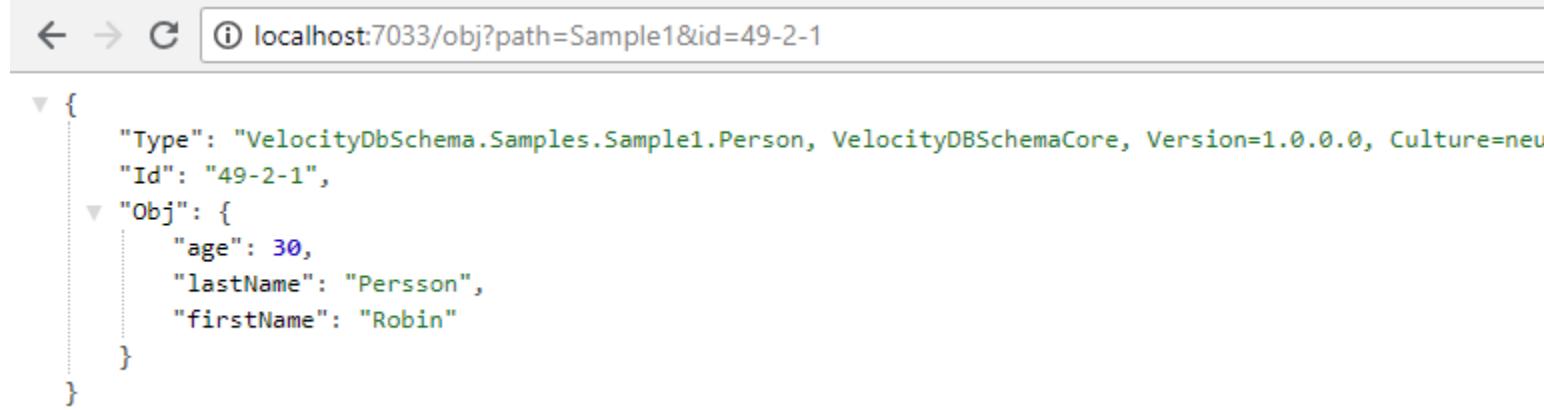
Database Manager

Schema Connectivity Add Connection...

- ▷ Host: "Asus2" Path: "C:/Databases/DatabaseManager" 86-2-1
- ▷ Host: "asus2" Path: "C:\Databases\Velocity" 86-2-2
- ▲ Host: "asus2" Path: "C:\Databases\sample1" 86-2-3
 - ▷ DatabaseManager.Model.FederationInfo 86-2-3
 - ◀ Host: "asus2" Path: "c:\\databases\\sample1" 2-2-2
 - ▷ VelocityDb.DatabaseLocation 2-2-2
 - ▷ 0 Transactions version: 7 pages: 4
 - ▷ 1 Schema version: 2 pages: 2
 - ▷ 2 DatabaseLocations version: 2 pages: 3
 - ▷ 5 version: 7 pages: 4
 - ▷ 6 VelocityDb.Sync.Change version: 7 pages: 3
 - ◀ 49 VelocityDbSchema.Samples.Sample1.Person version: 1 pages: 3
 - ▷ Page: 0 size: 8955 stored size: 8983 offset: 622 compression: None noEncryption version: 1 objects: 6
 - ▷ Page: 1 size: 58 stored size: 86 offset: 8 compression: None noEncryption version: 6 objects: 1 of type: VelocityDb.AutoPlace
 - ◀ Page: 2 size: 500 stored size: 528 offset: 94 compression: None noEncryption version: 6 objects: 20 of type: VelocityDbSchema.Samples.Sample1.Person 49-2-1
 - ◀ VelocityDbSchema.Samples.Sample1.Person 49-2-1
 - firstName : Robin
 - lastName : Hood
 - age : 30
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-2
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-3
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-4
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-5
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-6
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-7
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-8
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-9
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-10
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-11
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-12
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-13
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-14
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-15
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-16
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-17
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-18
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-19
 - ▷ VelocityDbSchema.Samples.Sample1.Person 49-2-20
 - ▷ 51 VelocityDbSchema.NUnit.LargeObject version: 1 pages: 3

In screen capture above we see an active database session coming from DatabaseManager which includes a core server connection to databases in Sample.

Viewing object



A screenshot of a web browser displaying a JSON object. The URL in the address bar is `localhost:7033/obj?path=Sample1&id=49-2-1`. The JSON structure is as follows:

```
{  
    "Type": "VelocityDbSchema.Samples.Sample1.Person, VelocityDBSchemaCore, Version=1.0.0.0, Culture=neutral",  
    "Id": "49-2-1",  
    "Obj": {  
        "age": 30,  
        "lastName": "Persson",  
        "firstName": "Robin"  
    }  
}
```

Updating object

Here we use the excellent tool called [Postman](#)

The screenshot shows the Postman application interface. At the top, there's a navigation bar with 'File', 'Edit', 'View', and 'Help' options. Below the navigation bar are buttons for 'New', 'Import', 'Runner', and 'My Workspace'. A 'Filter' search bar is also present.

The main area displays a 'History' section on the left, which includes a 'Clear all' button and a log entry for a 'POST' request to 'localhost:7033/obj?path=Sample1'. The main workspace shows a 'POST' request to 'localhost:7033/obj?path=Sample1'. The 'Body' tab is selected, showing a JSON payload:

```
1 {  
2   "Type": "VelocityDbSchema.Samples.Sample1.Person",  
3   "Id": "49-2-1",  
4   "Obj": {  
5     "age": 21,  
6     "lastName": "Persson",  
7     "firstName": "Robin"  
8   }  
9 }
```

Below the body, the 'Headers' tab shows four entries. The 'Body' tab is selected, showing the raw JSON. The 'Pretty' view shows the JSON with indentation:

```
1 49-2-1 updated
```

Now back in Chrome browser we can see that object was updated.

localhost:7033/obj?path= Sample1&id=49-2-1

```
{  
    "Type": "VelocityDbSchema.Samples.Sample1.Person, VelocityDBSchemaCore, Version=1.0.0.0, Culture=neutral",  
    "Id": "49-2-1",  
    "Obj": {  
        "age": 21,  
        "lastName": "Persson",  
        "firstName": "Robin"  
    }  
}
```

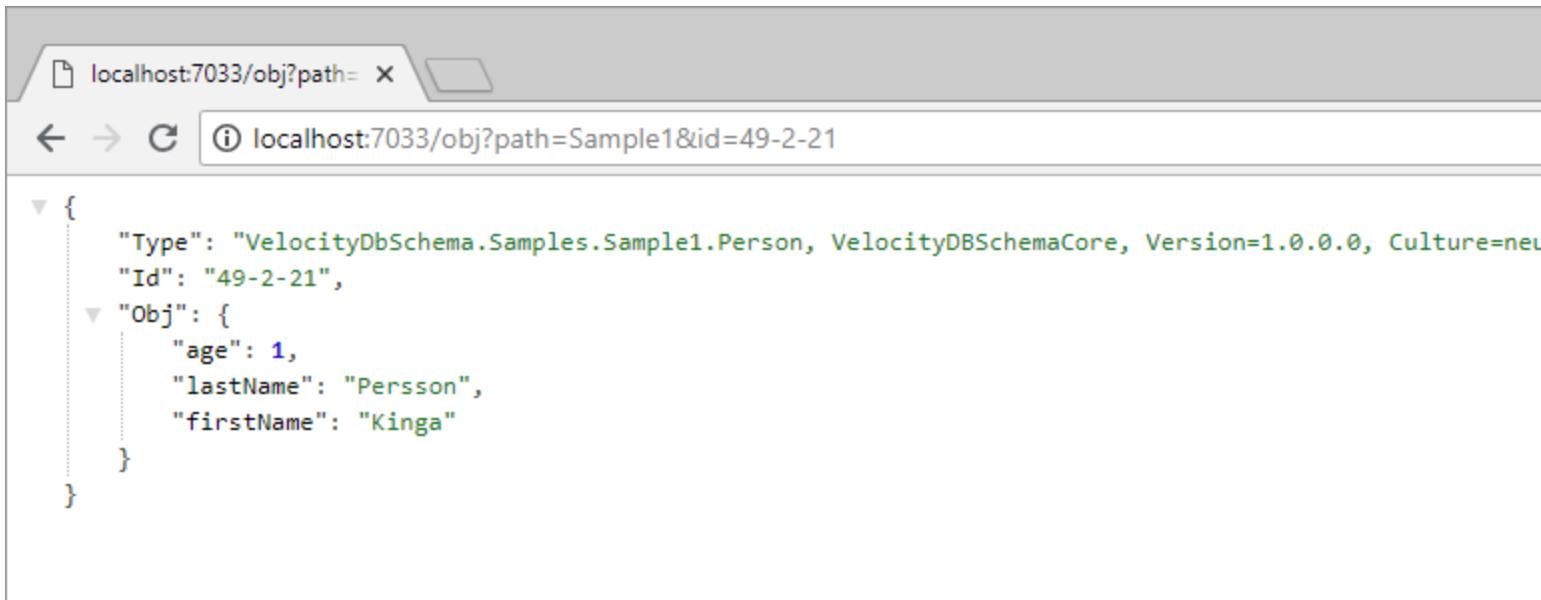
Adding Object

The screenshot shows the Postman application interface. The top navigation bar includes 'File', 'Edit', 'View', 'Help', 'New', 'Import', 'Runner', 'My Workspace', and 'Invite'. The left sidebar has a 'Filter' search bar, tabs for 'History' (selected) and 'Collections', and a 'Clear all' button. Under 'History', there are two entries: a POST request to 'localhost:7033/obj?path=Sample1' and another POST request to the same endpoint. The main workspace shows a POST request to 'localhost:7033/obj?path=Sample1'. The 'Body' tab is selected, showing a JSON payload:

```
1 {  
2   "Type": "VelocityDbSchema.Samples.Sample1.Person",  
3   "Obj": {  
4     "age": 1,  
5     "lastName": "Persson",  
6     "firstName": "Kinga"  
7   }  
8 }
```

The 'Headers' tab shows four items. Below the request, the 'Body' tab is selected, showing the JSON payload. The 'Cookies' and 'Headers' tabs are also visible. At the bottom, there are buttons for 'Pretty', 'Raw', 'Preview', 'Text' (with a dropdown), and a copy icon.

Not that we **didn't** specify Id in the Json body of the message.



```
{  
    "Type": "VelocityDbSchema.Samples.Sample1.Person, VelocityDBSchemaCore, Version=1.0.0.0, Culture=neutral",  
    "Id": "49-2-21",  
    "Obj": {  
        "age": 1,  
        "lastName": "Persson",  
        "firstName": "Kinga"  
    }  
}
```

Seetings for the VelocityDBCoreserver

To change settings you have to first stop the servers: VelocityDBServer and VelocityDBCoreserver in the Services Window. You may have to stop them multiple times as shutdown isn't graceful right now and it restarts. Windows makes it hard to edit the file. You may have to save edited version somewhere else and then move the file via an Administrator command line shell. Sorry about that.

Settings file is in: C:\Program Files (x86)\VelocityDB\core (or similar path from your Windows drive)

core

Share View

> This PC > Local Disk (C:) > Program Files (x86) > VelocityDB > core

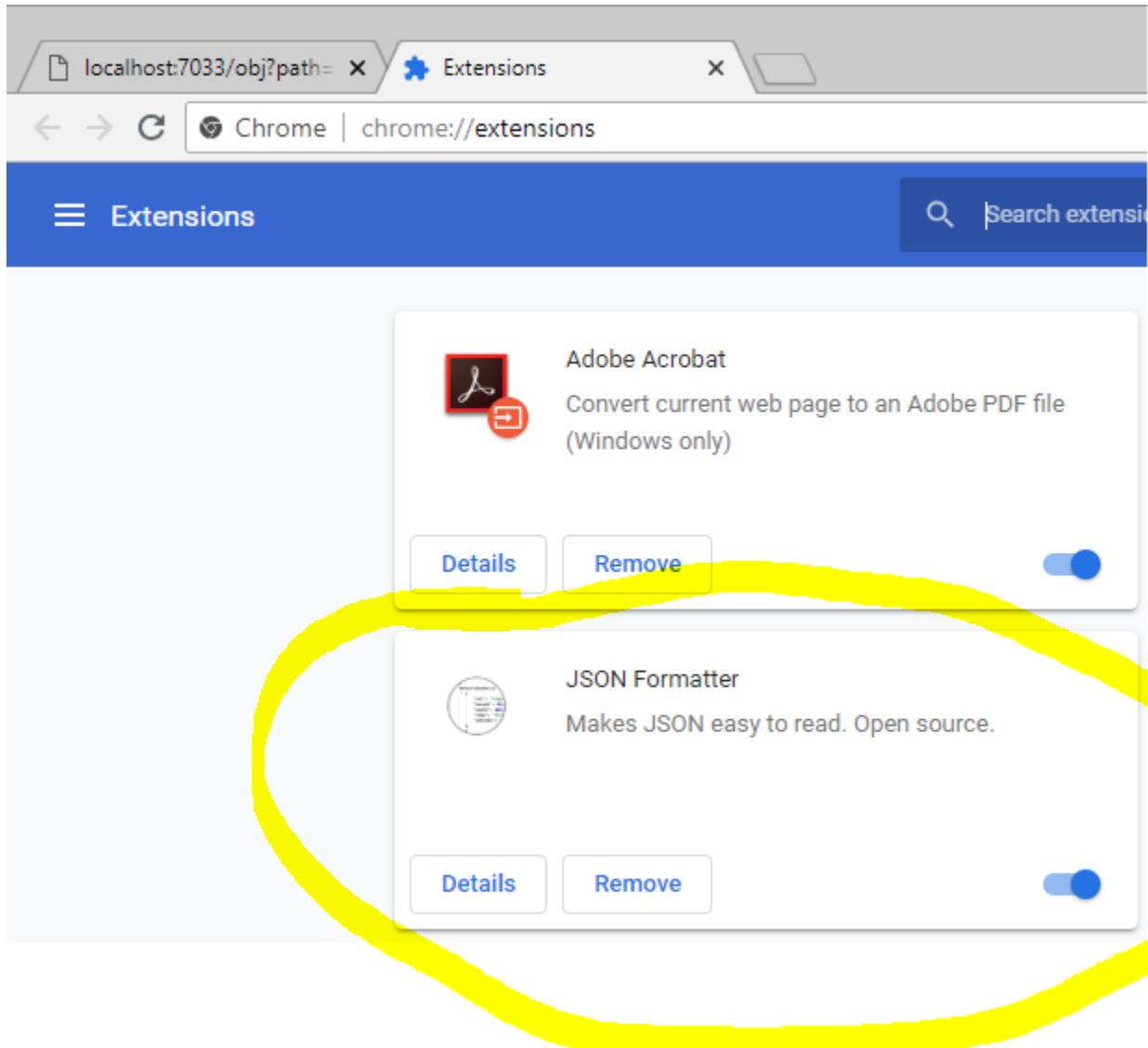
	Name	Date modified	Type
ss	api-ms-win-core-console-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-datetime-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-debug-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-errorhandling-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-file-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-file-l1-2-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-file-l2-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-handle-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-heap-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-interlocked-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-libraryloader-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-localization-l1-2-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-memory-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-namedpipe-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-processenvironment-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
ts	api-ms-win-core-processthreads-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
ls	api-ms-win-core-processthreads-l1-1-1.dll	7/25/2018 9:24 AM	Application extens
ls	api-ms-win-core-profile-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-rtlsupport-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-string-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-synch-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-synch-l1-2-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-sysinfo-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-timezone-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-core-util-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-conio-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-convert-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-environment-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-fsfileystem-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-heap-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-locale-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-math-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-multibyte-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-private-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-process-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-runtime-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-stdio-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-string-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-time-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
rr	api-ms-win-crt-utility-l1-1-0.dll	7/25/2018 9:24 AM	Application extens
	appsettings.Development.json	8/29/2018 1:01 PM	JSON File
	appsettings.json	9/8/2018 12:55 PM	JSON File

Schema: <http://json.schemastore.org/appsettings>

```
1  {
2    "Logging": {
3      "LogLevel": {
4        "Default": "Warning"
5      }
6    },
7    "AllowedHosts": "*",
8
9    "VelocityDBServer": {
10      "BaseDatabasePath": "c:/Databases",
11      "DoWindowsAuthentication": false,
12      "NumberOfWorkerThreads": 10,
13      "ServerActivityLogFile": null,
14      "TcpIpPortNumber": 7032,
15      "MaximumMemoryUse": 10000000000,
16      "Schema": [ "C:/VelocityDB/Sample1Core/bin/Release/netcoreapp2.1/VelocityDbSchemaCore.dll" ]
17    }
18  }
19 }
```

The server needs access to your **application schema** built as a **.Net Core 3.1 library**. A regular .Net library doesn't work as .Net Core Types differ from regular .Net (a Microsoft issue, not our). Specify path in "Schema" section of the appsettings, if multiple separate with a ,.

Chrome Json Formatter



With the formatter the JSON code looks much better!

Why installation ends up in Program Files (x86) instead of Program Files?

An issue is that Install Shield LE 2013 does not support 64bit installers so installation ends up in Program Files (86) instead of Program Files.

We use Install Shield LE 2013 which comes with Visual Studio. For VelocityDbServer service install we create a merge module using [WiX Toolset](#).

The latest version with Visual Studio 2013 is supposed to support 64 bit installers but we have not figured out how to do it yet. Be patient, we will solve it eventually or let us know how it's accomplished!

.NET CORE

This version of the VelocityDB library lets you build [portable apps](#) that can run on multiple platforms including: Windows, Linux and Mac. Reference VelocityDBCore.dll in your app or install the [VelocityDB NuGet](#).

This platform requires a default constructor as with [Universal Windows](#). The API provided by .Net Core libraries is not yet complete. Notably missing and causing performance/functionality issues for VelocityDB are:

1. [ResolveEventHandler](#)
2. [Assembly.LoadWithPartialName](#)
3. [Environment](#)
4. [public static Type GetType\(string typeName, Func<AssemblyName, Assembly> assemblyResolver, Func<Assembly, string, bool, Type> typeResolver, bool throwOnError\)](#)
5. [FormatterServices.GetUninitializedObject](#)
6. [AppDomain](#)
7. [Trace](#)

Consequences of missing API include: each persisted class must have a constructor with no parameters, a Type cannot be loaded if the assembly version is changed so we'll have to NOT update the assembly version of VelocityDBCORE.dll.

.NET 5 and .NET Standard 2.0

Most or all the above-mentioned missing API is now available with .NET 5 (was .NET Core), .Net Standard 2.0 is no longer missing any of this API.

Universal Windows

This version of the VelocityDB library lets you build [native Windows apps](#), compiles to machine code as with unmanaged C++ applications. Reference VelocityDBUniversalWindows.dll in your app or install the [VelocityDB NuGet](#).

This platform requires a default constructor as with [.Net CORE](#). The API provided by Microsoft for Universal Windows libraries is not yet complete. Notably missing and causing performance/functionality issues for VelocityDB are:

8. [System.Security.Cryptography](#)
9. [Thread](#)
10. [TcpClient](#)
11. [Environment](#)
12. [System.Reflection.Assembly](#)
13. [Assembly.LoadWithPartialName](#)
14. [Dns](#)
15. [public static Type GetType\(string typeName, Func<AssemblyName, Assembly> assemblyResolver, Func<Assembly, string, bool, Type> typeResolver, bool throwOnError\)](#)
16. [Type.GetTypeCode](#)
17. [DynamicMethod](#)
18. [FormatterServices.GetUninitializedObject](#)
19. [Console](#)
20. [AppDomain](#)
21. [Trace](#)

Consequences of missing API include: each persisted class must have a constructor with no parameters, a Type cannot be loaded if the assembly version is changed so we'll have to NOT update the assembly version of VelocityDBUniversalWindows.dll.

Where to store databases with Universal Windows?

We tested using this path: `Windows.Storage.ApplicationData.Current.LocalFolder.Path;`

We tried to set the `SessionBase`.`BaseDatabasePath` to this but then when ran into errors while doing the obfuscation of the library. We will try again! No obfuscation required with apps since they are compiled to binary code as with C++!

iOS

The installation directory contains iOS\VelocityDB.dll and iOS\VelocityDB.xml, add a reference to this DLL if you are targeting iOS for your application. Some of the VelocityDB code is not as efficient on iOS due to System.Reflection.Emit not being supported, see reasons [here](#).

Android

The installation directory contains Android\VelocityDB.dll and Android\VelocityDB.xml, add a reference to this DLL if you are targeting Android for your application. You can develop Android applications using Visual Studio 2015 with Xamarin. We currently don't have any sample applications but follow the [Android Xamarin guides](#) and ask us if you get stuck with how to use it with VelocityDB.

Asp.Net Identity

A driver for storing user credentials in VelocityDB using [Asp.Net Identity](#) is part of the VelocityDB.sln and a sample Web site, AspNetIdentitySample, is also provided that uses asp.Net Identity with VelocityDB. These projects require .Net 4.5.2 or higher.

Application Deployment and VelocityDB license check

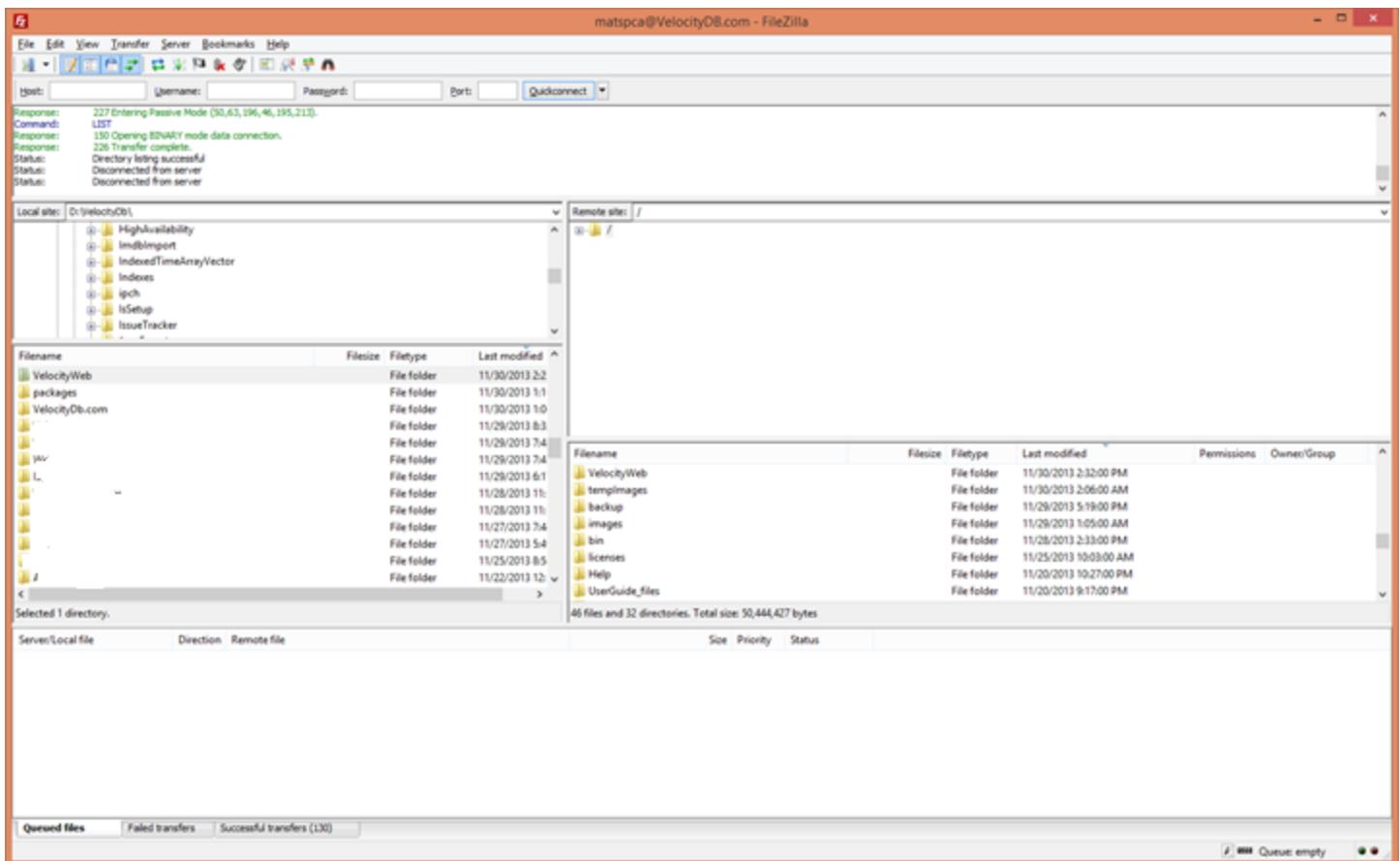
Normally you need to deploy the license database, 4.odb, but if you are publishing your application as open source or your database files in a publicly accessible directory then do not include 4.odb since that would enable unlicensed usage of VelocityDB. Instead [register](#) all your persistent classes prior to deployment and deploy database 1.odb which then contains your entire database schema. VelocityDB may do a license check whenever database schema is added to or is updated.

Setting Up the sample Web Site (VelocityWeb) on a hosting web site (in this case GoDaddy)

The VelocityDB sample solution contains a sample web application using VelocityDB, here we show you how to deploy this application.

Transfer all the files to your hosting account

Copy the entire directory named VelocityWeb to the root of your hosting directory. We use FileZilla (free software).



Login to your hosting provider to enable write access to a few of the directories in the application

The screenshot shows the GoDaddy Control Panel with the 'FTP File Manager' tab selected. The interface includes a sidebar for creating new directories and a main area displaying a list of files and folders. The list includes items like 'bin', 'CSS', 'Database', 'Errors', 'Images', 'IssuesDatabase', 'obj', 'Properties', 'Save', 'Secure', 'About.aspx', 'About.aspx.cs', 'About.aspx.designer.cs', 'Contact.aspx', 'Contact.aspx.cs', 'Contact.aspx.designer.cs', 'Default.aspx', 'Default.aspx.cs', 'Default.aspx.designer.cs', 'InstallDatabases.aspx', 'InstallDatabases.aspx.cs', and 'InstallDatabases.aspx.designer.cs'. The table has columns for 'Filename', 'Size', 'Date Modified', 'File Type', and 'Permissions'. A copyright notice at the bottom states 'Copyright © 1999 - 2013, All rights reserved.'

FTP File Manager: velocitydb.com - Internet Explorer

File Edit View Favorites Tools Help My Account My Account Hosting Details FTP File Manager: velocitydb.com Google

CONTROL PANEL Domains Hosting Email

Home Files & FTP Databases More Help My Account Feedback

FTP File Manager

velocitydb.com (Change Account)

Create New Directory

Set Permissions

Advanced Permissions

Multiple items selected may not have matching permissions. Any changes made will apply to all items.

Set permissions for selected folders.

Inherit (Inherit permissions from parent directory)

Read (Directory contents are visible to users)

Write (Applications can write to this directory)

Reset all children to inherit (All subdirectories will be reset to inherit from current directory)

OK Cancel

37 Directories and Files (5 Selected) Refresh List Page Size: 25 Page: 1 of 2

Filename	Size	Date Modified	File Type	Permissions
[Parent Directory]	—	11/30/2013 1:32 PM	Directory	
bin	—	11/30/2013 1:32 PM	Directory	
CSS	—	11/30/2013 1:32 PM	Directory	
<input checked="" type="checkbox"/> Database	—	11/30/2013 1:32 PM	Directory	
<input checked="" type="checkbox"/> Errors	—	11/30/2013 1:32 PM	Directory	
<input checked="" type="checkbox"/> Images	—	11/30/2013 1:32 PM	Directory	
<input checked="" type="checkbox"/> IssuesDatabase	—	11/30/2013 1:32 PM	Directory	
<input type="checkbox"/> obj	—	11/30/2013 1:32 PM	Directory	
<input type="checkbox"/> Properties	—	11/30/2013 1:32 PM	Directory	
<input checked="" type="checkbox"/> Save	—	11/30/2013 1:32 PM	Directory	
<input type="checkbox"/> Secure	—	11/30/2013 1:32 PM	Directory	

Copyright © 1999 - 2013, All rights reserved.

The screenshot shows a Windows-style interface for managing files on a server. At the top, there's a browser-like header with tabs for 'File Manager' and 'Special Domain ...'. Below it is a navigation bar with links like 'Home', 'Files & FTP', 'Databases', 'More', and 'Help'. A 'My Account' link is also present. The main area is titled 'FTP File Manager' and shows a hierarchical file tree on the left under 'Create New Directory'. On the right, there's a 'Set Permissions' dialog box with sections for 'Advanced Permissions' and checkboxes for 'Inherit', 'Read', 'Write', and 'Reset all children to inherit'. Below the dialog is a table listing 37 directories and files, with 5 selected. The table has columns for 'Filename', 'Size', 'Date Modified', 'File Type', and 'Permissions'. The 'Permissions' column contains icons for each item. The footer of the interface includes a copyright notice: 'Copyright © 1999 - 2013, All rights reserved.'

Create an application root virtual directory for the new web application

The screenshot shows the IIS Management interface in a web browser. The title bar reads "IIS Management - Internet Explorer". The main menu includes "File", "Edit", "View", "Favorites", "Tools", and "Help". The toolbar has icons for "Create", "Edit", "Remove", and "Pipeline". The top right corner shows "Welcome, Mats" and "Logout". Below the menu, there's a "CONTROL PANEL" section with links for "Domains", "Hosting", and "Email". The main content area is titled "IIS Management" and shows a "Creating directories" section. It instructs users to enter a directory name and path, and select settings like "Anonymous Access", "Directory Browsing", and "Set Application Root". A table lists existing virtual directories: "Content Root" (selected), "velocitydb", "velocitydb1", "velocitydb2", and "velocitydb3". The bottom of the page includes a copyright notice: "Copyright © 1999 - 2013, All rights reserved."

The screenshot shows the IIS Management interface in a web browser. The left sidebar contains a section titled "IIS Management" with instructions on managing virtual directories. The main area displays a table of virtual directories under "Content Root".

Directory	Status	Action
Content Root	Setup	
L...	Pending Setup	
velocityweb		

Copyright © 1999 - 2013, All rights reserved.

Wait a few minutes then point your browser at your web application

The screenshot shows a web browser window with the URL <http://www.velocitydb.com/velocityWeb/>. The page title is "VelocityWeb". The header includes a "Log In" button and a "Select Language" dropdown. The main content area features a blue banner with the text "Sample Web Site using VelocityDB for all persistent storage." Below the banner, there is descriptive text about the site's purpose and a section titled "IssueTracker brief introduction" with detailed information about its features and usage.

This is a [web site](#) with some code shared with VelocityDB.com. It shows how to store user information in one set of databases and issues/bugs tracking in another set of databases. The web site we cloned, VelocityDB.com, also have code for license generation/management, charts and other tricks. We hope you can learn how to build your own web sites with VelocityDB by looking at this sample code. Another sample web site using VelocityDB for data storage is [OnlineStoreFinder.com](#). If anyone is interested in building a shopping site managing, querying and comparing millions of products, that is the sample to study. Send us an [email](#) to discuss it.

IssueTracker brief introduction

The IssueTracker consists of issues, users, projects, components and versions. Any user can create issues but only an admin user can create/modify projects, components and users. The very first user to connect to the issue tracker becomes admin automatically. An admin user can decide what other users are admin users. The code is not elegant but a developer's first attempt in using Ajax controls for a rather complex application. I am sure you can do better!

Email notification is built in but you need to update the code with your own credentials, search for NetworkCredential in the source code for places to update.

If you transferred your application directory with databases then install your databases in their new location.

The screenshot shows a Microsoft Internet Explorer window with the URL <http://www.velocitydb.com/VelocityWeb/InstallDatabases.aspx>. The page title is "VelocityWeb". A blue header bar contains the text: "If you move databases from one server to another, you need to install the databases with local host name and paths." Below this, a note explains the purpose of three text boxes: "The first textbox contains a secret password you have made up and is hard coded in the source code for this page. The second text box contains success/failure messages after you press Button. The third box contains an optional host name field, enter the domain of your web site there when you use install on your hosting we site, like VelocityWeb.com". There are three text input fields: the first is empty, the second contains the text "velocitydb.com@d:\hosting\xxx\xhtml\velocityweb\issuesdatabase", and the third contains "VelocityDB.com". A "Button" button is located to the right of the second text box.

If all is well, you are done, access the application and the databases!

The screenshot shows a Microsoft Internet Explorer window with the URL <http://www.velocitydb.com/VelocityWeb/Se>. The page title is "VelocityWeb - Issue Tracking". A blue header bar contains the text: "Use icons instead of text state strings". Below this, a note is present. The main content is a table showing two issues:

ID	Priority	Created	Status	Resolution	Summary	Component	Version	Category	ReportedBy	LastUpdatedBy	LastUpdated	AssignedTo	DueDate
1-1		29 November 2013			vbbvbbv	VelocityDB - Web Site	0.8		matspca	matspca	29 November 2013	matspca	01 January 0001
1-18		30 November 2013			lkl	VelocityDB - Web Site	0.8		matspca	matspca	30 November 2013	matspca	01 January 0001