Firebird 3: provider-based architecture, plugins and OO approach to API

Alex Peshkov

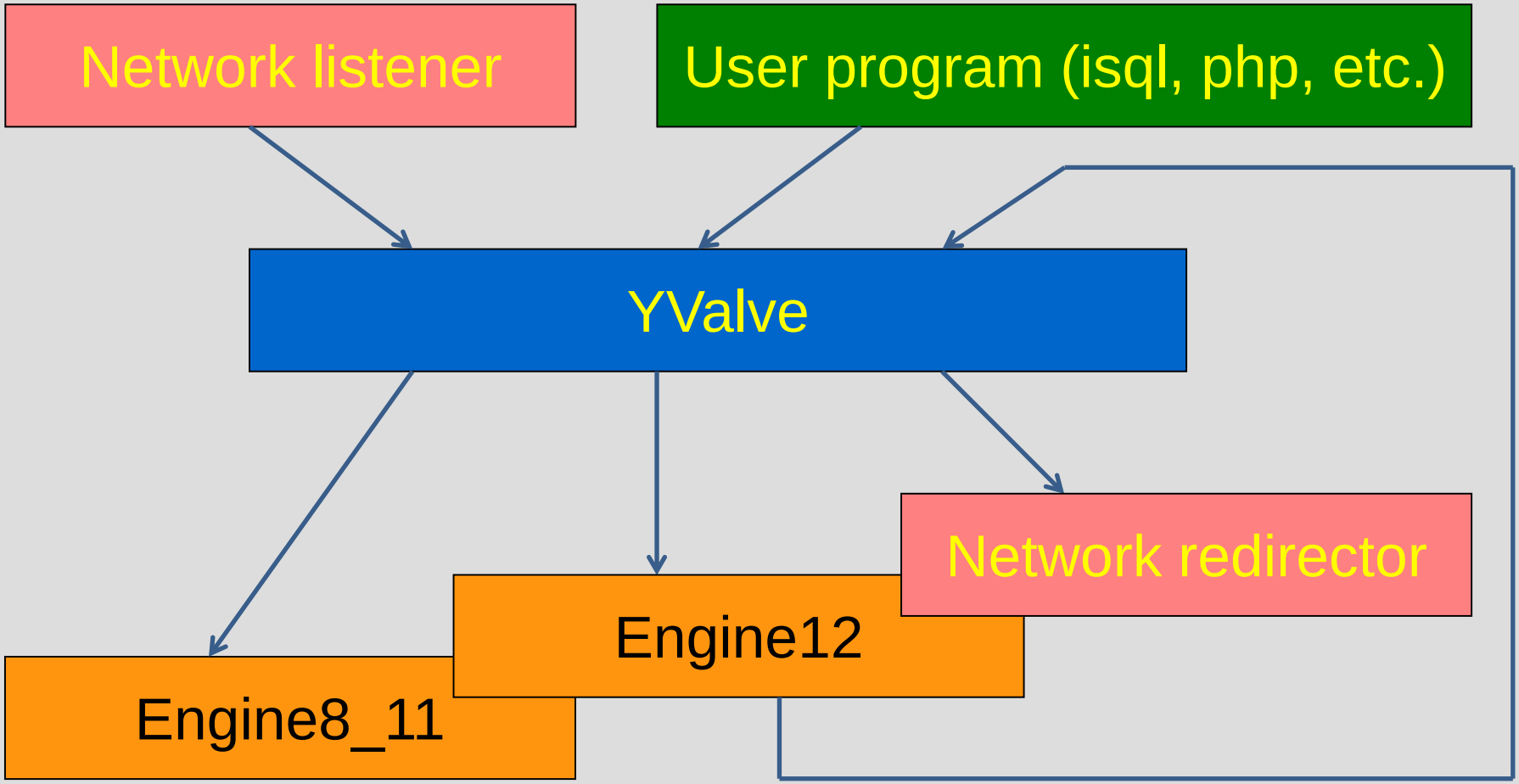
Firebird Foundation

2011

Architectural goals of Firebird3

- Provide more and better ways for users to extend functionality of firebird
- How to do it:
  - Introduce (or may be restore ?) provider-based architecture
  - Introduce (or may be extend ?) plugins

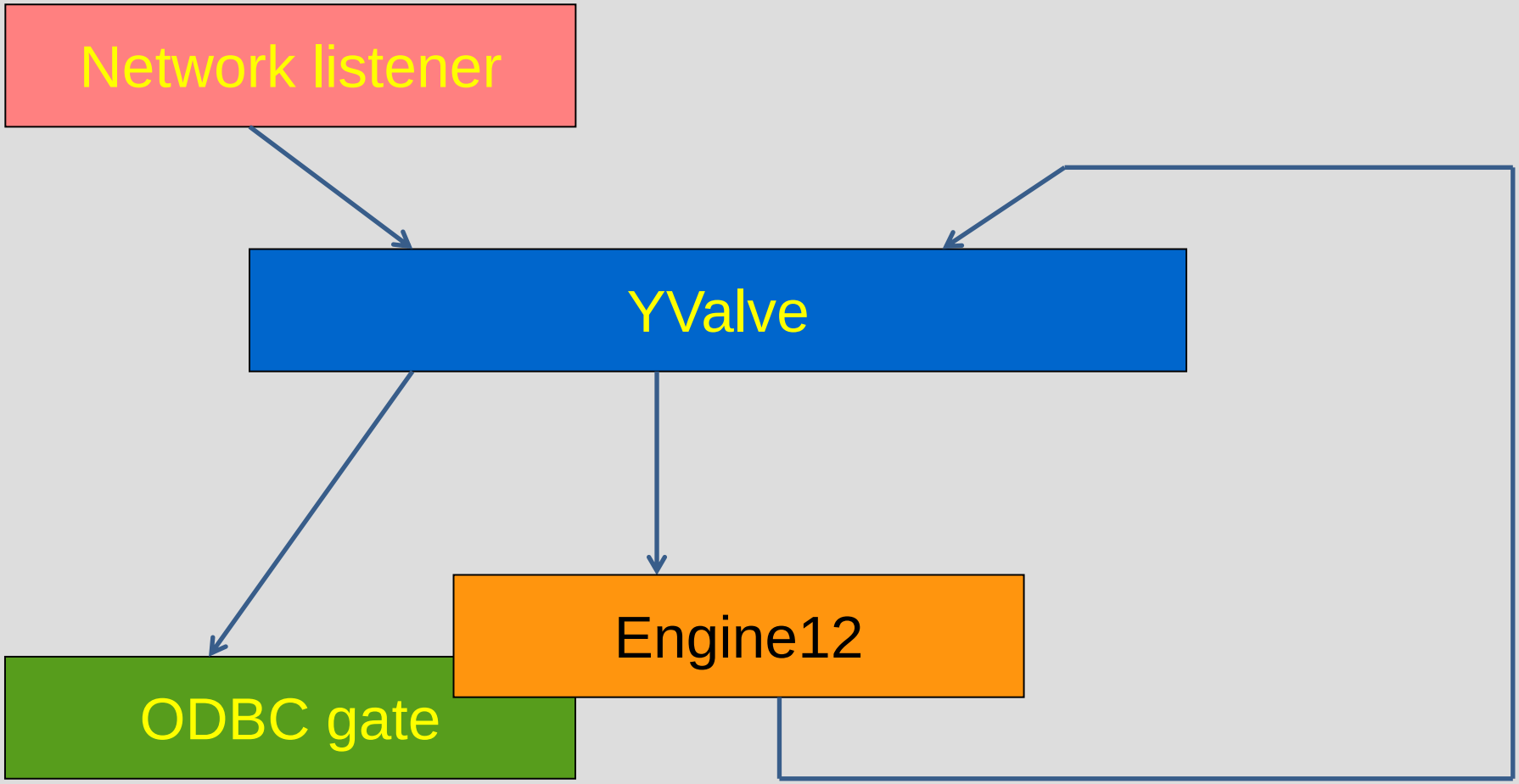
Providers – based architecture (OSRI)



Clients

Pro

Server with additional provider



Clients

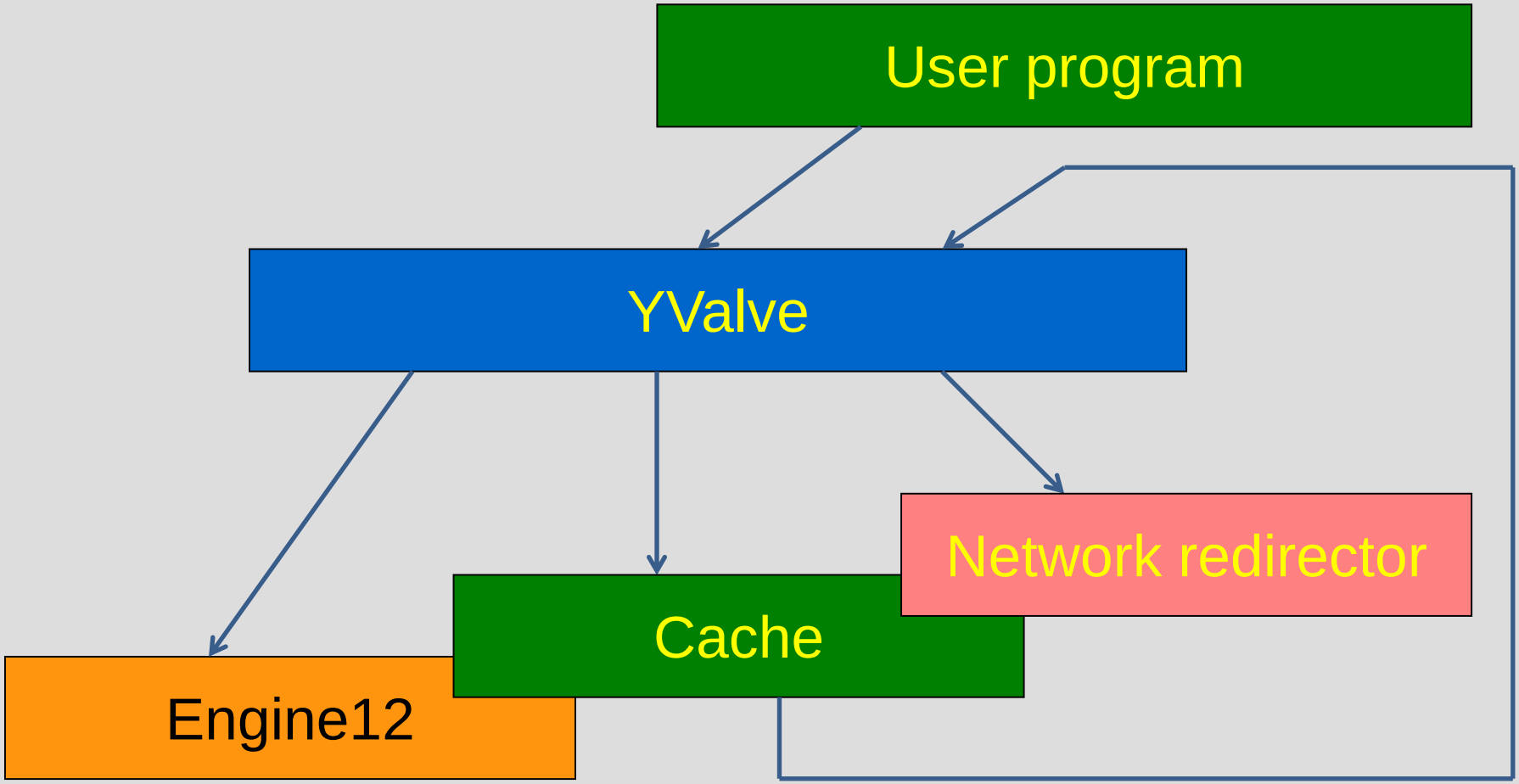
Pro

Server with additional provider

EXECUTE STATEMENT 'ODBC SPECIFIC OPERATOR'
ON EXTERNAL 'ODBC://odbc_datasource_name'

- Engine12:
  - Attach Database 'ODBC://odbc_datasource_name'
- YValve:
  - Tries known providers, including ODBC gate
- ODBC gate:
  - Recognizes 'ODBC://' prefix
  - Calls appropriate ODBC function to establish connection

Client with additional provider



Clients

Pro

Client with additional provider

- Client:
  - Attach Database 'CACHE://SRV/dbAlias'
- Yvalve:
  - Tries known providers, including CACHE
- CACHE:
  - Recognizes 'CACHE://' prefix
  - Can use 'INET://somehost/dbAlias' to access remote data
  - Can use embedded connection to access cached data

Plugins

- Provide almost unlimited capabilities of extending firebird with what user needs
  - UDFs and blob filters are also a kind of plugins with specific interface and calling rules
- Require (like UDFs) special care to avoid malicious code, executed in server context
  - all plugins, not described explicitly in configuration file, are loaded from $(root)/plugins, slash in names is not permitted
  - if one provides path information in explicit plugin description – he should care about it himself

Plugins

- May be plugged only into specially prepared points of main firebird code
- Firebird 3 will support the following types of plugins:
  - Trace;
  - External engines;
  - Authentication (server/client) and users' management;
  - Crypt (network and may be database).

Plugins

- Have interface, specific for each predefined point in firebird code
- Have common rules of load/unload and configuration
- Have common interface, controlling that common features

Plugins and providers-base architecture

- Provider is invoked from specific point of a code (from yValve)
- Providers should be loaded/unloaded to/from firebird process address space

- Providers can and should be treated as a special kind of plugins
  - this avoids adding special code, duplicating one for plugins

Choosing API

- Functional API
  - Follows existing (isc_attach_database) style
- Object-oriented API
  - Used in a lot of modern software
  - Saves resources when loading plugin
- Backward compatibility at yValve level for providers API

Interfaces

- Firebird API contains 2 types of objects:
  - Interface - C++ class with pure-virtual only functions;

```
class IIntUserField : public IUserField
{
public:
        virtual int FB_CARG get() = 0;
        virtual void FB_CARG set(int newValue) = 0;
};
```

    - Simplified form, used later

```
class IIntUserField : public IUserField
{
        int get();
        void set(int newValue);
};
```

Interfaces

- Firebird API contains 2 types of objects:
  - Structure - C struct, containing POD (plain old data) only;

```
struct FbMessage
{
        const unsigned char* blr;
        unsigned char* buffer;
        unsigned int blrLength;
        unsigned int bufferLength;
};
```

Master interface

- Provides access to other interfaces
- Stands separate from the others, cause created (from user POV) not by any other interface, but by API function:
  - IMaster* fb_get_master_interface();
- This is the only one new API function, required to support OO API

Common rules

- All interfaces are derived from IVersioned, IDisposable or IRefCounted (last two are also derived from IVersioned).
  - All plugins are derived from IPluginBase (derived from IRefCounted).
  - Interfaces guaranteed lifetime:
    - IRefCounted – as long as not released last time,
    - IDisposable – as long as not disposed,
    - non of this (just versioned) – according to lifetime of outer object (which created that interface)

IVersioned – version of interface

- Firebird interfaces are not COM interfaces – we support multiple versions of same interface.
- Interface version can be upgraded by code, receiving interface from other module.
- Interface version is always equal to total number of virtual functions in it.
- Use of upgraded interface does not cause any delays when using it's functions.

IVersioned – version of interface

```
class IVersioned {
   int getVersion();
   IPluginModule* getModule();
};
```

IVersioned – version of interface

- Upgrade is supported by IVersioned and function:
  - IMaster::upgradeInterface(
    - IVersioned* toUpgrade,
    - int desiredVersion,
    - struct UpgradeInfo* upgradeInfo).

```
struct UpgradeInfo
{
    void* missingFunctionClass;
    IPluginModule* clientModule;
};
```

IVersioned – version of interface

- Samples of missingFunctionClass

```
class NoEntrypoint {
   virtual void FB_CARG noEntry(IStatus* s) {
       s->set(Arg::Gds(isc_wish_list).value());
   }
};

class IgnoreMissing {
   virtual int FB_CARG noEvent() {
      return 1;
   }
}
```

IVersioned – version of interface

- Calling functions in upgraded interface

```
class IService : public IRefCounted
{
        void detach(IStatus* status);
        void query(IStatus* status,
            int sendLength, char* sendItems,
            int receiveLength, char* receiveItems,
            int bufferLength, char* buffer);
        void start(IStatus* status,
            int spbLength, char* spb);
};
```

Explicit lifetime control

- Required when interface is created at one place and destroyed at another
- IDisposable – used in interfaces, not intended to be passed from thread to thread

```
class IDisposable : public IVersioned {
        void FB_CARG dispose();
};
```

- Used as base for IStatus

Explicit lifetime control

- IRefCounted – OK to pass across thread boundary, can be destroyed by any thread in safe way

```
class IRefCounted : public IVersioned
{
        void addRef();
        int release();
};
```

- Base of many interfaces, including IPluginBase

IPluginBase

- Base interface for all primary plugin interfaces

```
class IPluginBase : public IRefCounted {
    void setOwner(IRefCounted*);
    IRefCounted* getOwner();
};
```

- Plays key role when unloading plugin module from process space

IPluginFactory

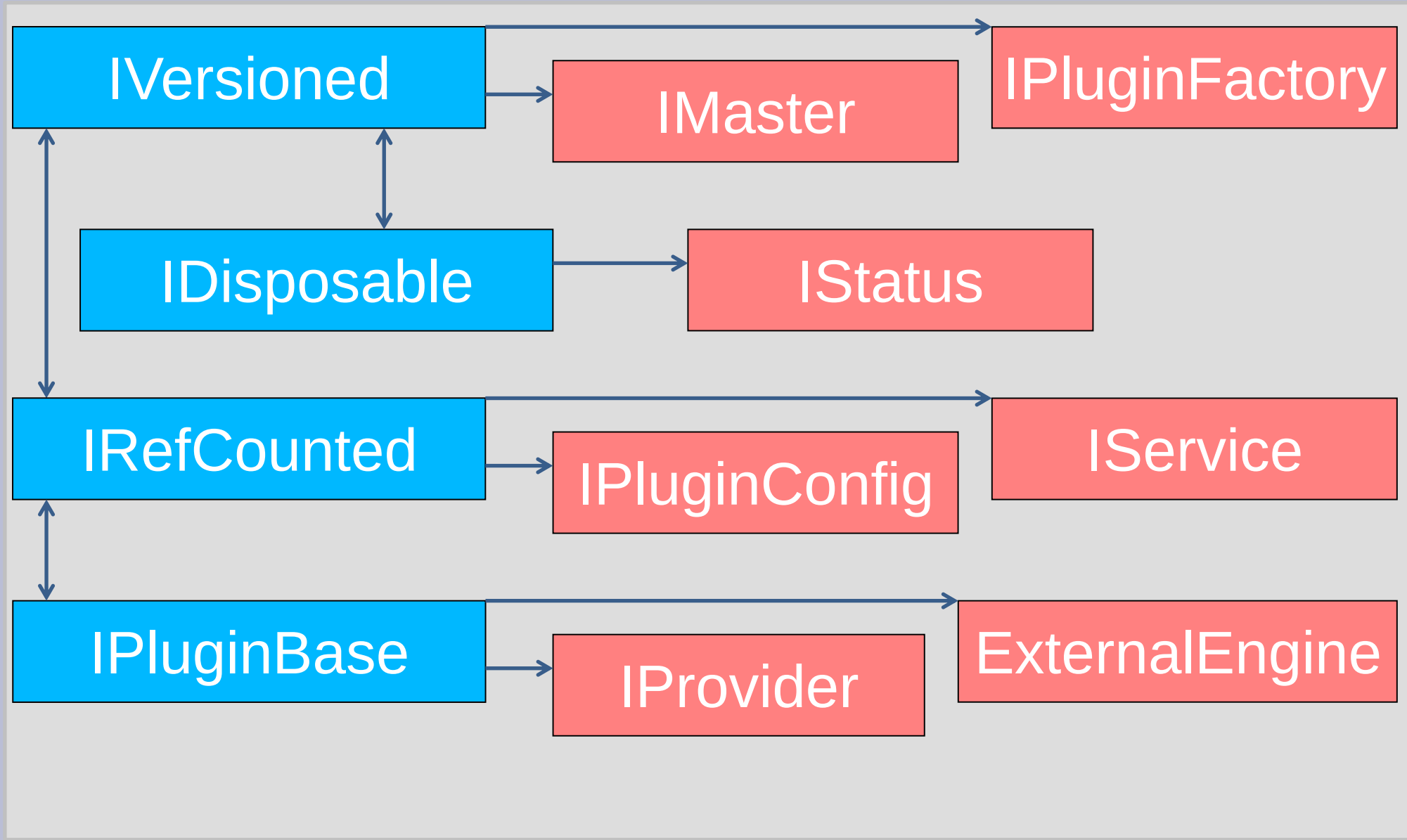
- Created by plugin module to register plugin in firebird:

```
class IPluginFactory : public IVersioned {
      IPluginBase* createPlugin
            (IPluginConfig* factoryParameter);
};
```

- Registered in plugin manager:

```
IPluginManager::registerPluginFactory
   (int pluginType,
    char* name,
    IPluginFactory* factory)
```

Interfaces hierarchy



C++ wrapper over interfaces

- Helps to perform repeating tasks when working with interfaces

```
class Abc: public IVersionedIface { .... }
#define ABC_VERSION (FB_VERSIONED_VERSION + 3)

template <class C, int V> class VersionedIface;

Abc* abcInstance =
    new VersionedIface<Abc, ABC_VERSION>;
```

C++ wrapper over interfaces

- Other useful templates:

```
template <class C, int V> class AutoIface;
template <class C, int V> class DisposeIface;
template <class C, int V> class RefCntIface;
```

  - missing release() method

```
template <class C, int V> class StdPlugin;
template <class P> SimpleFactory;
```

Configuring plugins

- List of plugins to be used
  - Set in firebird.conf for each plugin type
  - Default values:

  - AuthServer = Srp, Win_Sspi
  - AuthClient = Srp, Win_Sspi, Legacy_Auth
  - UserManager = Srp
  - TracePlugin = fbtrace
  - Providers = Remote,Engine12,Loopback

Configuring plugins

- Plugin's specific configuration
  - Depends only upon plugin itself
- Advantages of using standard configuration
  - Saves time/efforts when writing plugin code
  - Plugin's users configure it in familiar manner
- Standard configuration methods
  - File of predefined format [param=value] in predefined place [$(root)/plugins/]
  - Record in common for all plugins file

Configuring plugins

- New configurartion file plugins.conf
  - Has 2 types of records – config and plugin

- Config record – stores plugin-specific data

```
Config = ConfName {
  Param1 = Value1
  Param2 = Value2
}
```

- Plugin record - sets rules of plugin's loading

Configuring plugins

- Plugin record format:

```
Plugin = Name {
  Module = /path/to/module
  RegisterName = regName
  Config = ConfName
  ConfigFile = /path/to/file
}
```

- Defaults:

```
Plugin = % {
  Module = $(root)/plugins/%
  RegisterName = %
  ConfigFile = $(root)/plugins/%.conf
}
```

Configuring plugins

- When we need plugins.conf
  - Names conflict in 2 plugins, taken from different places
  - Plugin = Crypt1 {
    Module = $(root)/plugins/Crypt1
    RegisterName = BestCrypt
  - }
  - Plugin = Crypt2 {
    #Module = $(root)/plugins/Crypt2
    RegisterName = BestCrypt
  - }

Configuring plugins

- When we need plugins.conf
  - Use same plugin with different configuration
  - Plugin = first {
    Module = $(root)/plugins/abc
    RegisterName = abc
    #ConfigFile = $(root)/plugins/first.conf
  - }
  - Plugin = second {
    Module = $(root)/plugins/abc
    RegisterName = abc
  - }

Accessing configuration data from plugin

- Configuration is passed to plugin when it is created:
  IPluginBase* IPluginFactory::createPlugin (IPluginConfig* factoryParameter)

- Typical implementation (in SimpleFactory):

```
IPluginBase* createPlugin(IPluginConfig* fPar)
{
        P* plugin = new P(fPar);
        plugin->addRef();
        return plugin;
}
```

Accessing configuration data from plugin

- IPluginConfig layout

```
class IPluginConfig : public IRefCounted {
    const char* getConfigFileName();
    IConfig* getDefaultConfig();
    IFirebirdConf* getFirebirdConf();
};
```

- Related method in IPluginManager

```
IConfig* getConfig(const char* filename);
```

Accessing configuration data from plugin

- IConfig and IConfigEntry layout

```
class IConfig : public IRefCounted {
    IConfigEntry* find(const char* name);
    IConfigEntry* findValue(char* name, char* val);
    IConfigEntry* findPos(char* name, int pos);
};

class IConfigEntry : public IRefCounted {
    const char* getName();
    const char* getValue();
    IConfig* getSubConfig();
};
```

Accessing configuration data from plugin

- Sample

```
IConfig* group(IConfig* iConf, char* entry)
{
    IConfigEntry* ce = findValue("Group", entry);
    return ce ? ce->getSubConfig() : NULL;
}

int count(IConfig* iConf, char* param)
{
    int n;
    for (n = 0; iConf->findPos(param, n); ++n);
    return n;
};
```

Accessing firebird.conf from plugin

- Accessing global file
  iPluginMgr->getConfig("$(root)/firebird.conf");

- Accessing per-database configuration
  class IFirebirdConf : public IRefCounted {
      int getKey(char* name);
      int asInteger(int key);
      const char* asString(unsigned int key);
  };

Accessing firebird.conf from plugin

- Sample – from secure remote passwords

```
IFirebirdConf* cnf;

SrpManagement(IPluginConfig* par)
    : cnf(par->getFirebirdConf())
{ }

void start(IStatus* status, ILogonInfo* logonInfo)
{
  int dbKey = cnf->getKey("SecurityDatabase");
  char* secDbName = config->asString(dbKey);
```

Using OO provider's API

- Main provider's API - IProvider

```
class IProvider : public IPluginBase {
  IAttachment*  attachDatabase (IStatus* status,
    char* fileName, int dpbLength, char* dpb);
  IAttachment* createDatabase(IStatus* status,
    char* fileName, int dpbLength, char* dpb);
  IService* attachServiceManager(IStatus* status,
    char* service, int spbLength, char* spb);
  void shutdown(IStatus* status,
    int timeout, int reason);
};
```

Using OO provider's API

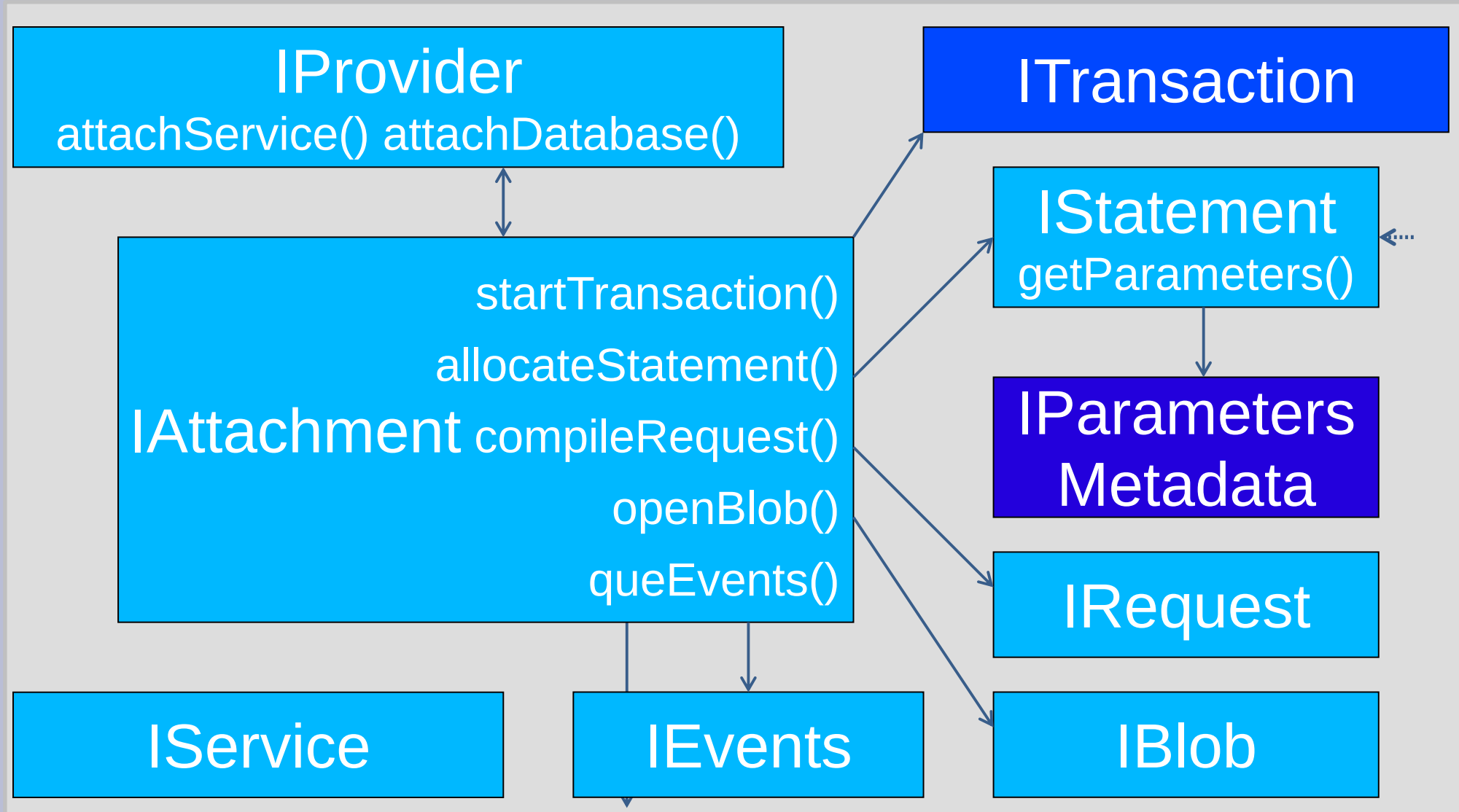
- Clients get access to provider's API using IMaster interface:

```
IStatus* status = iMaster->getStatus();
IProvider* dispatch = iMaster->getDispatcher();
IAttachment *att = dispatch->attachDatabase
                (status, “employee”, dpbLength, dpb);
dispatch->release();

// work with attachment ...

att->detach(status);
status->release();
```

Provider's interfaces



Provider's interfaces

- IStatement – new message description

```
class IStatement : public IVersioned {
   int fetch(IStatus* status, FbMessage* msg);
   // … other functions
};

isc_dsql_fetch_m(STATUS*, FB_API_HANDLE*,
   USHORT blr_length, SCHAR* blr, USHORT
   msg_length, SCHAR* msg);
```

Provider's interfaces

- IEvents – new name, old object

```
class IEventCallback : public Iversioned {
   void callbackFunction(int length, char* events);
};

IEvents* IAttachment::queEvents(IStatus* status,
   IEventCallback* callback, int len, char* events);

class IEvents : public IRefCounted {
   void cancel(IStatus* status);
};
```

Provider's interfaces

```
class IParametersMetadata : public IVersioned {
   int getCount(IStatus* status);
   char* getField(IStatus* status, int index);
   char* getRelation(IStatus* status, int index);
   char* getOwner(IStatus* status, int index);
   char* getAlias(IStatus* status, int index);
   int getType(IStatus* status, int index);
   bool isNullable(IStatus* status, int index);
   int getSubType(IStatus* status, int index);
   int getLength(IStatus* status, int index);
   int getScale(IStatus* status, int index);
};
```

Provider's interfaces

- ITransaction – new API functions, related with 2PC (distributed transactions)

```
class ITransaction : public IRefCounted {
   // prepare, commit, rollback, etc...
   ITransaction* join(IStatus* status,
                      ITransaction* tra);
   ITransaction* validate(IStatus* status,
                      IAttachment* attachment);
   ITransaction* enterDtc(IStatus* status);
};
```

Distributed transactions coordinator

- Starting transaction in single database

```
IAttachment::startTransaction(IStatus* status,
                              int tpbLength, char* tpb);
```

- DTC interface

```
IDtc* iDtc = iMaster->getDtc();
```

Distributed transactions coordinator

- DTC interface

```
class IDtc : public Iversioned {
   ITransaction* start(IStatus* status, int cnt,
                       DtcStart* components);
   ITransaction* join(IStatus* status,
            ITransaction* one, ITransaction* two);
};

struct DtcStart {
   IAttachment* attachment;
   char* tpb;
   int tpbLength;
};
```

Distributed transactions coordinator

- Sample A

```
DtcStart comp[2] = { {att1, 0, 0}, {att2, 0, 0} };
ITransaction* distr = iDtc->start(status, 2, comp);
```

- Sample B

```
ITransaction* t1 =
        att1->startTransaction(status, 0, 0);
ITransaction* t2 =
        att2->startTransaction(status, 0, 0);
ITransaction* distr = t1->join(status, t2);
```

Master interface

```
class IMaster : public IVersioned {
   IStatus* getStatus();
   IProvider* getDispatcher() = 0;
   IPluginManager* getPluginManager();
   int upgradeInterface(IVersioned* toUpgrade,
        int desiredVersion, UpgradeInfo* upInfo);
   ITimerControl* getTimerControl();
   IDtc* getDtc() = 0;
};
```

External Engine

```
class ExternalEngine : public IPluginBase {
   ExternalFunction* makeFunction(Error* error,
            ExternalContext* context,
            IRoutineMetadata* metadata,
            BlrMessage* inBlr, BlrMessage* outBlr);
   ExternalProcedure* makeProcedure(...);
   ExternalTrigger* makeTrigger(Error* error,
            ExternalContext* context,
            IRoutineMetadata* metadata);
};
```

External Engine

- Interfaces used
  - ExternalContext – attachment of external engine to database.
  - IRoutineMetadata – metadata of procedure /trigger /function (name, entry point, etc.)
  - Both interfaces passed to plugin from firebird

External Engine

- Interfaces exported – procedure, triger and function

```
class ExternalProcedure : public Disposable {
    ExternalResultSet* open(Error* error,
                ExternalContext* context,
                void* inMsg, void* outMsg);
};

class ExternalResultSet : public Disposable {
        virtual bool FB_CALL fetch(Error* error);
};
```

External Engine

- Existing plugins:
  - UDR – user defined routines on C/C++
    - will be install with firebird server
  - JAVA
    - will be isntalled with jaybird

External Engine

- JAVA sample – Java class

```
public class FbRegex {
    public static String replace(String regex,
                        String str, String replacement) {
        return str.replaceAll(regex, replacement);
    }
}
```

External Engine

- JAVA sample – SQL operator

```
create function regex_replace (
        regex varchar(60), str varchar(60),
        replacement varchar(60)
    )
    returns varchar(60)
  external name
    'org.firebirdsql.example.fbjava.FbRegex.replace (
        java.lang.String, java.lang.String,
        java.lang.String
    )
    return java.lang.String'
  engine java;
```

External Engine

- UDR sample – C++ boost-enhanced

```
FB_UDR_BEGIN_PROCEDURE(gen_rows2)
  FB_UDR_EXECUTE_MESSAGE_PROCEDURE
  ( (FB_INTEGER, start)
    (FB_INTEGER, end)
  ,
    (FB_INTEGER, result) )
      { out->result = in->start – 1; }

  FB_UDR_FETCH_PROCEDURE
      { return out->result++ < in->end; }
FB_UDR_END_PROCEDURE
```

External Engine

- UDR sample – SQL operator

```
create procedure gen_rows2 (
        start_n integer not null,
        end_n integer not null
) returns (
        n integer not null
)
    external name 'udrcpp_example!gen_rows2'
    engine udr;
```

Trace

```
class TraceFactory : public IPluginBase {
   ntrace_mask_t /*64 bit*/ trace_needs();
   TracePlugin*  trace_create(IStatus* status,
                              TraceInitInfo* init_info);
};

class TraceInitInfo : public IVersioned {
   TraceConnection* getConnection();
   TraceLogWriter* getLogWriter();
   // .........
};
```

Trace

```
class TraceConnection : public IVersioned {
   int getConnectionID();
   char* getDatabaseName();
   int FB_CARG getProcessID();
// ....
};

class TraceLogWriter : public IRefCounted {
   size_t write(const void* buf, size_t size);
};
```

- Also controls audit/trace mode

Trace

```
class TracePlugin : public IRefCounted {
   char* trace_get_error();
   int trace_attach(TraceConnection* connection,
      ntrace_boolean_t create_db,
      ntrace_result_t att_result);
   int trace_transaction_start(
      TraceConnection* connection,
      TraceTransaction* transaction,
      size_t tpb_length, ntrace_byte_t* tpb,
      ntrace_result_t tra_result);
// .....................
};
```

Authentication

- 3 types of authentication plugins:
  - Server – checks whether client correct or not
  - Client – prepares data for validation by server
  - User manager (not always required)

  - enum AuthResult {AUTH_SUCCESS, AUTH_CONTINUE, AUTH_FAILED, AUTH_MORE_DATA};

Authentication

```
class IAuthServer : public IPluginBase {
        AuthResult  authenticate(IStatus* status,
            AuthServerBlock* sBlock, IAuthPar* par);
        AuthResult getSessionKey(IStatus* status,
                        char** key, int* keyLen);
};
class AuthServerBlock : public IVersioned {
        char* getLogin();
        char* getData(int* length);
        void putData(int length, void* data);
};
```

Authentication

```
class IAuthClient : public IPluginBase {
        AuthResult  authenticate(IStatus* status,
            AuthClientBlock* sBlock);
        AuthResult getSessionKey(IStatus* status,
                    char** key, int* keyLen);
};
class AuthClientBlock : public IVersioned {
        char* getLogin();
        char* getPassword();
        char* getData(int* length);
        void putData(int length, void* data);
};
```

Authentication

- 4 plugins in firebird 3
  - Secure remote password protocol
  - Windows - trusted authentication
  - Linux – ssh-like handshake
  - Legacy (DES on client)

Secure remote password

- Up to 20 symbols in password
- Password is never passed over the wire
- Resistant to many attacks, including 'man in the middle'
- Can generate strong crypt keys on both client and server during authentication
- Does not require additional client-server roundtrips due to changes in network protocol

Authentication

```
class IManagement : public IPluginBase {
   void start(IStatus* status, ILogonInfo* lgnInfo);
   int execute(IStatus* status, IUser* user,
                                    IListUsers* callback);
   void commit(IStatus* status);
   void rollback(IStatus* status);
};
```

Authentication

```
class ILogonInfo : public IVersioned {
   char* FB_CARG name();
   char* FB_CARG role();
   int FB_CARG forceAdmin();
   char* FB_CARG networkProtocol();
   char* FB_CARG remoteAddress();
   int FB_CARG authBlock(char** bytes);
};
```

Authentication

```
class IUser : public IVersioned {
   int operation();
   ICharUserField* userName();
   ICharUserField* password();
   ICharUserField* firstName();
   ICharUserField* lastName();
   ICharUserField* middleName();
   ICharUserField* groupName();
   IIntUserField* FB_CARG uid();
   IIntUserField* FB_CARG gid();
   IIntUserField* FB_CARG admin();
   void FB_CARG clear();
};
```

Authentication

```
class IUserField : public IVersioned {
   int entered();
   void setEntered(int newValue);
};

class ICharUserField : public IUserField {
   char* get() = 0;
   void set(char* newValue) = 0;
};
```

Crypt

```
class ICrypt : public IPluginBase {
    void setKey(IStatus* status, int length,
                void* key);
      void transform(IStatus* status, int length,
                     void* to, void* from);
};
```

Thanks for your attention!