Purple

A Data-Flow-triggered, Plug-In-based Computational Engine using Verse

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Computational What?

- Interesting way to implement internals of traditional 3D creativity packages
  - Tools/Modifiers
  - Constraint Evaluation/Enforcement
- Very general, above is example, not full goal
- Focus on data processing, not I/O or storage
- Internals *really* separated from user interface
- Encourage distributed development

The Point?

- There are several, somewhat overlapping
- Implement the back-end of a 3D package, using Verse for the front-end
  - Reap Verse's benefits (networked, multi-user, ...)
- Allow building modeling application
  - Of interest as next-generation Blender?
- Improve Verse experience
- Provide a nice playground for programmers
  - Plug-ins easy to develop
  - Hoping for community

History

- Original concept from Eskil Steenberg, Verse's inventor
- Discussed with and judged as being of interest to Blender by Ton Roosendaal
  - Ton and Eskil met at SIGGRAPH 2002
- Implementation started Summer 2004, by me
  - As part of the Uni-Verse project, BF is partner
  - All code in CVS at blender.org

Plug-Ins

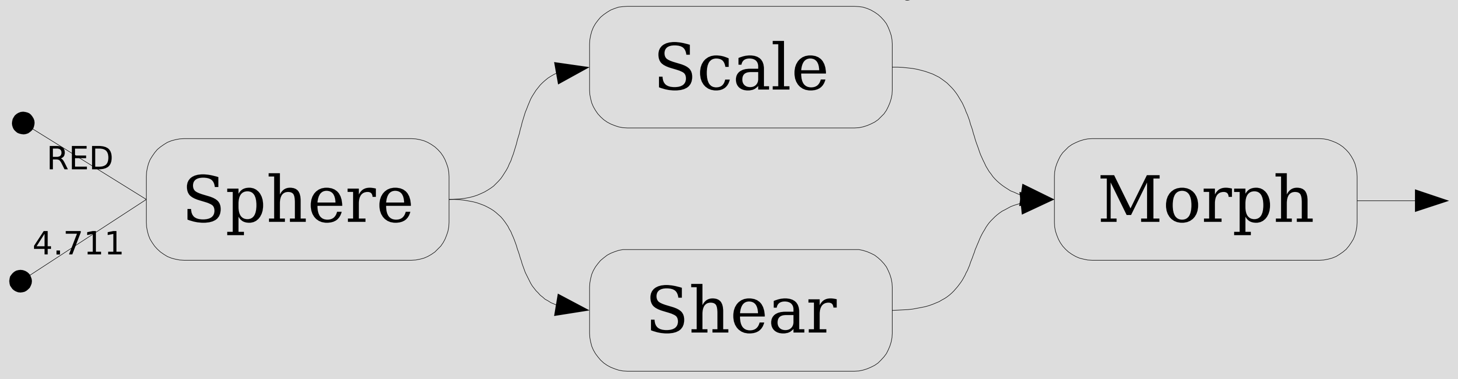
- Computation expressed by running plug-ins
- Aggregated by connecting plug-ins into *graphs*
- Set of inputs
  - Loosely typed
- Single logical output
  - Multiple independent values
- Reasonably easy access; better focus
- Heuristics allow this-to-that connections as often as possible
  - Avoid errors, let *something* happen

Examples

- Modeling Primitives
  - Easy to do parametric primitives
  - Purple does I/O and storage
  - One-parameter cube in ~60 lines of C
- Bitmap Filters
  - Reasonably direct access
  - Writing filters can be rewarding
- Constraints, Combinatorial Logic, Tests (“Intelligence”)
- Whatever else you feel like...

Data Flows

- Plug-in runs when input(s) change
- Input can come from user, e.g. a constant
  - Create a red sphere...
  - ...with radius 4.711 units
- Input can come from other plug-in's output
  - Causes re-computation to flow through graph
  - Models construction history



Purple Engine

- Plug-ins run by Purple engine program
- Implemented as a Verse client!
  - Operates on shared data
  - Client/server distribution just happens
  - Opens up major sharing possibilities
- Mirrors all data
  - Hides network round trips when possible
  - Local data makes things easier
- Loads plug-ins, manages execution

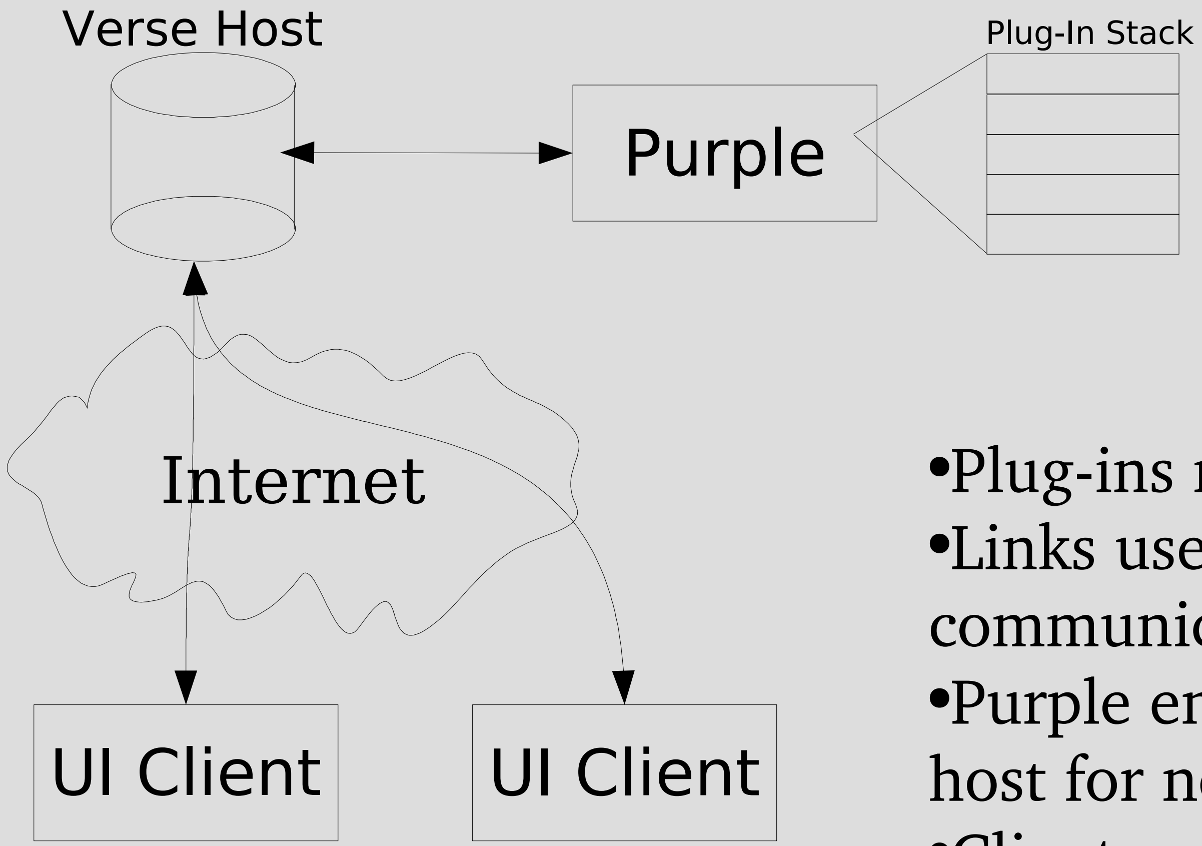
No UI

- Purple Engine is pure computational code, no user interface
- Intended to be remotely controlled by dedicated UI clients
- Allows computation/tools to be developed separately from UI
- No such client exists today :/
  - Idea: incorporate Purple control into Connector

Controlling Purple

- Separating out the UI places requirements on Purple:
    - Publish a list of available plug-ins
    - Publish a list of existing graphs
    - Graph descriptions
    - Support graph editing
- Information published using Verse standard text node, holding XML data
    - Very detailed, allows UI to do clever things
- Graph descriptions are also XML
- Graph editing through Verse avatar methods

System View



•Plug-ins run in Purple process
•Links use the Verse protocol to communicate
•Purple engine runs close to host for network performance
•Clients can run wherever

Plug-In Programming

- A C API, defined in single header purple.h
  - Verse core currently required (verse.h)
- Four distinct classes of calls:
  - Init – describe plug-in to the engine core
  - Input – read out input values
  - Node – work with various aspects of Verse nodes
  - Output – cause data to appear at output
- Initialization done once; sets compute callback
  - More (meta, state, N plug-ins per library, ...)
- Engine calls compute() when inputs change

More on Computation

- Plug-in code is run in a cooperative multi-tasking fashion; never interrupted by Purple
  - Forces plug-in programmer to think a little
  - This might change in future versions :)
  - Parallel execution of plug-ins is desired, too
  - Plugin-returns “done” or “call again soon”
- The Purple engine knows what is connected to each input, and can run `compute()` when something changes
  - Coarse filtering, but hopefully good enough

Plug-In Code Example

```
#include “purple.h”

static PComputeStatus compute(PPInput input[], PPOutput output, void *state)
{
    real32   x = p_input_real32(input[0]),     /* Read out inputs. Heuristics. */
             y = p_input_real32(input[1]);

    p_output_real32(output, x + y);            /* Emit sum as real32 result. */
    return P_COMPUTE_DONE;                     /* We're done for this time. */
}

void init(void)  /* Purple runs this when plug-in loads. */
{
    p_init_create(“add-as-real32”);            /* User-visible plug-in name. */
    p_init_input(0, P_VALUE_REAL32, “x”, P_INPUT_DONE);    /* Two inputs. */
    p_init_input(1, P_VALUE_REAL32, “y”, P_INPUT_DONE);
    p_init_compute(compute);
}
```

- API tries hard to be clean
- P_ prefix used for Purple constants, types, and functions
- Actual `compute()` function is basically a single statement, x+y
- Inputs are referenced by index, init-name is for UI uses

About `compute()`

- The compute() callback:

```
PComputeStatus compute(PPInput input[],
                       PPOutput output,
                       void *state);
```

- Gets array of inputs
  - As many as created w/ `p_init_input()`
  - The type is “Purple Port, Input”
- Gets single output port
- Gets state pointer (managed by Purple)
- Returns done/not done status

Inputting Nodes

- Plug-in might require a node as its input
- Kind of problematic, design-wise
  - What to connect to input in UI?
  - Need explicitness for dependency tracking
- Solved using built-in plug-in, “plugin-input”
  - Has string input, outputs node of that name
  - Magically runs `compute()` not only when string changes, but when named *node* changes, too!
  - Gives UI something known to manage

More Plug-In Code

```
#include “purple.h”

static PComputeStatus compute(PPInput input[], PPOutput output, void *state)
{
    PINode   *node = p_input_node(input[0]);   /* Get node, if available. */

    if(node != NULL)
        p_output_uint32(output, strlen(p_node_name_get(node)));
    return P_COMPUTE_DONE;
}

void init(void)
{
    p_init_create(“name-length”);         /* User-visible plug-in name. */
    p_init_input(0, P_VALUE_MODULE, “node”, P_INPUT_DONE); /* Must be “internal”. */
    p_init_compute(compute);
}
```

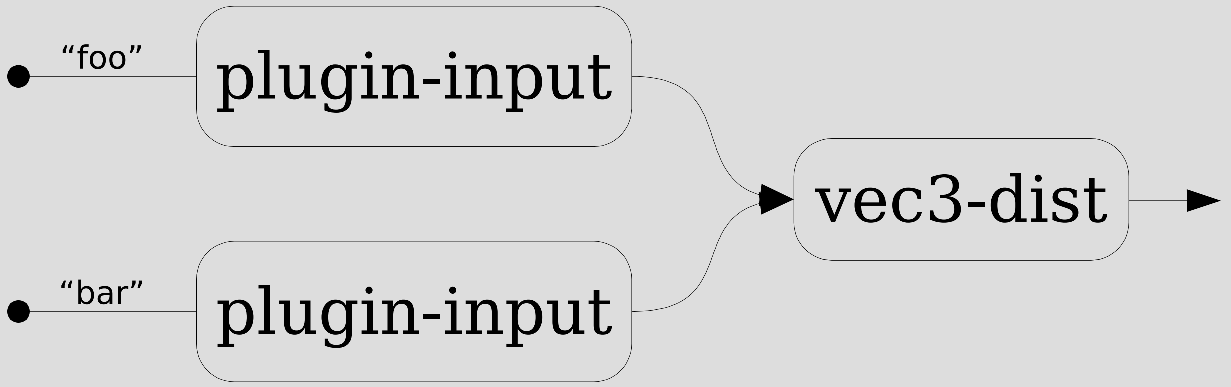
- `P_VALUE_MODULE` signals to UI that the plug-in needs to be connected to the output of another plug-in, such as plugin-input
- The test in `compute`() protects libc's `strlen`() from `NULL`
- It is fine to skip output if conditions aren't right

Still More Code

```
#include “purple.h”

static PComputeStatus compute(PPInput input[], PPOutput output, void *state)
{
    const real32 *v1 = p_input_real32_vec3(input[0]),
                 *v2 = p_input_real32_vec3(input[1]);

    p_output_real32(output, sqrtf(powf(v1[0] – v2[0], 2.0f) +
                                  powf(v1[1] – v2[1], 2.0f) +
                                  powf(v1[2] – v2[2], 2.0f));
    return P_COMPUTE_DONE;
}

void init(void)
{
    p_init_create(“vec3-dist”);
    p_init_input(0, P_VALUE_REAL32_VEC3, “v1”, P_INPUT_DONE);
    p_init_input(1, P_VALUE_REAL32_VEC3, “v2”, P_INPUT_DONE);
    p_init_compute(compute);
}
```

- Above can be used to measure distance between object nodes
- No need to explicitly input nodes; heuristics help here

Using vec3-dist



- The plugin-input instances output nodes
- vec3-dist reads real32_vec3's
- Heuristics convert nodes into vec3
  - For object nodes, position is returned
  - Also possible to be more explicit

Explicit Node Access

```
#include “purple.h”

static PComputeStatus compute(PPInput input[], PPOutput output, void *state) {
    PINode  *n1 = p_input_node(input[0]), *n2 = p_input_node(input[1]);

    if(p_node_type_get(n1) == V_NT_OBJECT && p_node_type_get(n2) == V_NT_OBJECT) {
        const real32 *v1 = p_node_o_pos_get(n1), v2 = p_node_o_pos_get(n2);
        p_output_real32(output, sqrtf(powf(v1[0] – v2[0], 2.0f) +
                                      powf(v1[1] – v2[1], 2.0f) +
                                      powf(v1[2] – v2[2], 2.0f));
    }
    return P_COMPUTE_DONE;
}

void init(void) {
    p_init_create(“obj-dist”);
    p_init_input(0, P_VALUE_MODULE, “n1”, P_INPUT_DONE);
    p_init_input(1, P_VALUE_MODULE, “n2”, P_INPUT_DONE);
    p_init_compute(compute);
}
```

- Explicitly access object nodes, testing to make sure
- Could also just output the position, and “graph it”
- Purple API uses Verse constants when convenient

More on Outputs

- Each plug-in has a single output port, passed to `compute()`
- Use `p_output_XXX()` to pass along values
- You can pass distinct values for the 9 simple types (e.g. integer = -12, uint32 = 56, ...)
  - Useful for heuristics and additional data
- You can also pass a (set of) full Verse nodes

Explicit Node Access

```
#include “purple.h”

static PComputeStatus compute(PPInput input[], PPOutput output, void *state) {
    real32   x = p_input_real32(input[0]), y = p_input_real32(input[1]);

    if(x > y) {
        p_output_boolean(output, TRUE);
        p_output_string(output, “yes”);
    }
    else {
        p_output_boolean(output, FALSE);
        p_output_string(output, “no”);
    }
    return P_COMPUTE_DONE;
}

void init(void) {
    p_init_create(“greater-than”);
    p_init_input(0, P_VALUE_REAL32, “x”, P_INPUT_DONE);
    p_init_input(1, P_VALUE_REAL32, “y”, P_INPUT_DONE);
    p_init_compute(compute);
}
```

- Emit both boolean and textual results

Accessing Nodes

- There are many calls for working with nodes
  - Follows Verse, `p_node_g_vertex_set_xyz()`
  - Will have more luxurious calls later on
    - Take advantage of locality of data set
    - Need more experience/pressure/time/ideas
- Nodes represented as opaque pointers
  - `PINode*` (input, read-only)
  - `PONode*` (output, read/write)
- Magic happens behind the scenes
  - Output synchronizer/command generator

Node Changes

- Changing node state adds to sync. queue
- Compared to input version, if available
  - Comparison generates commands (patches)
  - Utilizes XML version of the protocol spec, xslt
  - Commands sent will be returned by Verse host, node updated→fewer differences→done
  - Very expensive for structural changes... :/
- Creating new node adds it to special queue
  - Node is created, then synced as usual

Purple Status

- Been under way since May
- Single developer (me)
- No hard specification, evolves
- Code base is roughly 10,500 lines of C
  - Includes utility code (data structures)
  - Full rebuild in ~10 seconds on my puny laptop
- Lots of things still to do
  - Flesh out node API
  - Write synchronizer
  - ...

Questions?

Let's hear them!

mailto:emil@obsession.se
http://www.blender.org/modules/verse/