

OpenDreamKit Deliverable D4.2

Active/Structured Documents Requirements and existing Solutions

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Background and Motivation

- ▶ **Idea:** OpenDreamKit aims to build a math VRE on top of an ecosystem of specialist symbolic software systems.
- ▶ **Problem:** The user wants to have a seamless experience when interacting with math
- ▶ **Towards a Solution:** supply a joint User Interface that integrates the system
- ▶ **Existing Solutions:** in OpenDreamKit
 - ▶ **Project Jupyter:** joint web-based notebook UI for command-line systems (macro-scale)
 - ▶ **Active Documents:** embedding semantic services into documents (micro-scale)

1 Existing Solutions

Project Jupyter in a Nutshell

- ▶ **Idea:** Notebooks: text + interaction cells as a UI metaphor
- ▶ **Infrastructure:** rational reconstruction of iPython (sound software engineering)
 - ▶ Communication layer: start/maintain various computational kernels
 - ▶ document format: web-based notebooks with interaction cells
 - ▶ widgets: make notebooks interactive in the small

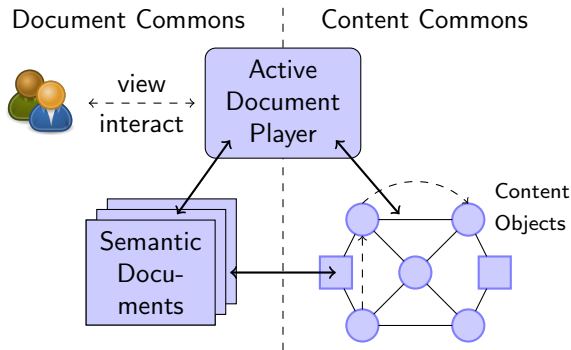
The screenshot displays a Jupyter Notebook titled "Lorenz Differential Equations". The notebook content includes:

- A title "Exploring the Lorenz System".
- Text: "In this Notebook we explore the Lorenz system of differential equations:"
- Mathematical equations:
$$\begin{aligned}\dot{x} &= \sigma(y - x) \\ \dot{y} &= \rho x - y - xz \\ \dot{z} &= -\beta z + xy\end{aligned}$$
- Text: "This is one of the classic systems in non-linear differential equations. It exhibits a range of complex behaviors as the parameters (σ, β, ρ) are varied, including what are known as chaotic solutions. The system was originally developed as a simplified mathematical model for atmospheric convection in 1963."
- An interactive cell with the following code:

```
In [7]: Interact(Lorenz, N=Fixed(10), angle=(0.,360.),  
                sigma=(0.0,50.0),beta=(0.,5),rho=(0.0,50.0))
```
- Below the code, there are sliders for "angle" (set to 308.2), "max_time" (set to 12), "sigma" (set to 10), "beta" (set to 2.6), and "rho" (set to 28).
- At the bottom, a 3D plot of the Lorenz attractor is shown, rendered with a colorful, semi-transparent surface.

The Active Documents Paradigm

- ▶ **Definition 0.1** The **active documents paradigm (ADP)** consists of
 - ▶ *semantically annotated documents* together with
 - ▶ background ontologies (which we call the **content commons**),
 - ▶ *semantic services* that use this information
 - ▶ a **document player** application that embeds services to make documents executable.



- ▶ **Example 0.2** Services can be program (fragment) execution, computation, visualization, navigation, information aggregation and information retrieval

Planetary at the Presentation/Structural Level

- ▶ Planetary can make use objects and relations at various levels,
- ▶ **Example 0.3 (arXivdemo: Document Structure and Presentational Math)**

The screenshot shows a web browser displaying an arXiv article page. The browser's address bar shows the URL `http://arxivdemo.mathweb.org/article/998/nucl-th.0011027`. The page header includes navigation links like "Dashboard", "Questions", "Activity", "Inbox", "smirea", "Articles", and "Books". The article title is "nucl-th.0011027 2011-01-11 16:18:17".

Annotations on the page highlight several Planetary features:

- Context Menu:** A pink box labeled "Context Menu (3 icons)" points to a small menu icon above the text "In terms of the AGS transition operator U_{11} the η elastic scattering amplitude is represented as".
- Discussion Thread:** A pink box labeled "Discussion Thread" points to a blue comment box containing the text "Guest: very long formula... Guest: What is M1 here? I have no idea... maybe file a bug report?".
- InfoMarkers:** A pink box labeled "InfoMarkers" points to two red circular icons on the right margin of the article text.
- FoldingBar:** A pink box labeled "FoldingBar" points to a horizontal bar at the bottom left of the article content.
- InfoBar:** A pink box labeled "InfoBar" points to a vertical bar on the right side of the article content.

The article content includes a section titled "§ 2. AGS formalism" and a mathematical equation:

$$U_{\beta\alpha}(z) = (1 - \delta_{\beta\alpha})G_0^{-1}(z) + \sum_{\gamma=1}^3 (1 - \delta_{\beta\gamma})T_{\gamma\alpha}(z)G_0^{-1}(z)$$

User Services at the Semantic Level in Planetary

Definition Lookup

$f \subseteq X \times Y$ is called a **partial function**, iff for all $x \in X$ there is at

Definition Lookup Results

DEFINITION:

Cartesian product:
 $A \times B := \{(a, b) \mid a \in A \wedge b \in B\}$, call (a, b) pair.

Semantic Folding

$$s = s_1 + v_1 \Delta t + \frac{1}{2} a \Delta t^2$$

Fold
Semantic Fold

$$s = s_1 + s_v + s_a$$

contribution from acceleration

Unit Conversion

City A is 9144ft from city B and 5164ft from city C.

Look-up Definition

convert to miles

convert to meters

convert to feet

convert to inches

convert to yards

convert the units

City A is 3048m from city B and 5164ft from city C.

Prerequisites Navigation

Prerequisites Graph for ./slides/dmath/en/sets-operations.tex – Planetary SandBox

Prerequisites Graph for ./slides/dmath/en/sets-operations.tex

```
graph TD
    THIS((THIS)) --> sets-relations((sets-relations))
    sets-relations --> sets-introduction((sets-introduction))
    sets-relations --> mathtalk-definitions((mathtalk-definitions))
    sets-relations --> relation1((relation1))
    sets-introduction --> dates((dates))
    mathtalk-definitions --> mathtalk((mathtalk))
    mathtalk-definitions --> highschool((highschool))
    mathtalk-definitions --> sequences((sequences))
    relation1 --> setname2((setname2))
    setname2 --> setname1((setname1))
    setname2 --> setname2
```

mathtalk, highschool, sequences

Mathematics uses a very effective technique for dealing with conceptual complexity. It usually starts out with discussing simple, basic objects and their properties. These simple objects can be combined to more complex, compound ones. Then it uses a definition to give a compound object a new name, so that it can be used like a basic one. In particular, the newly defined object can be used to form compound objects, leading to more and more complex objects that can be described succinctly. In this way mathematics incrementally extends its vocabulary by add layers and layers of definitions onto very simple and basic beginnings. We will now discuss four definition schemata that will occur over and over in this course.

Find: Q la Next Previous Highlight all Match case

User Services at the Formal Level in Planetary

- ▶ **Formal Level:** e.g. specification and verification in the LATIN Logic Atlas
 - ▶ flexible elision of brackets
 - ▶ argument reconstruction via external TWELF system
 - ▶ verification by the HETS system
- ▶ **Example 0.4** Adapting formal representations user preferences

```
document derived.omdoc
```

```
remote module FalsityExt
```

```
remote module NEGExt
```

```
theory IMPExt meta If
```

```
include IMP
```

```
imp2I : ((ded A → ded B → ded C) → ded A imp (B imp C))
```

```
      = [f:ded A → ded B → ded C]impI ([p:ded A]impI ([q:ded B]f p q))
```

```
imp2E : (ded A imp (B imp C) → ded A → ded B → ded C)
```

```
      = [p:ded A imp (B imp C)][q:ded A][r:ded B]impE (impE p q) r
```

```
remote module CONJExt
```

```
remote module DISJExt
```

```
remote module Equiv
```

type

ded A imp (B imp C)

infer type

reconstructed types

implicit arguments

implicit binders

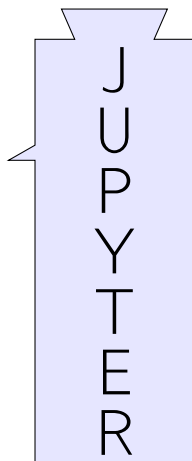
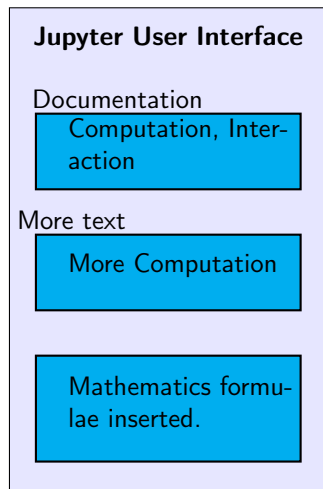
redundant brackets

Eold

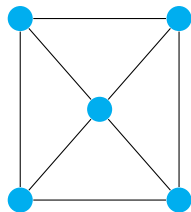
- ▶ Informal Active Documents: Weierstrass Equation in ODK Glossary
- ▶ Informal Active Documents: Weierstrass Equation in ODK Glossary
- ▶ Formal Active Documents: propositional logic in MMT

2 Towards a math VRE via a joint UI

Jupyter: Information Processing Architecture



Notebook



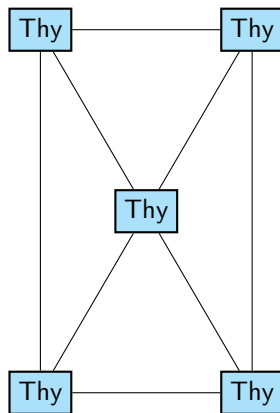
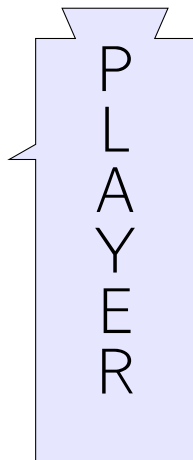
My Math Document

This is a sentence used to represent the interactivity between the text and the active document.

Among the text of an active document there are fields which can interact with the user such as:

Field 1

Field 2



Synthesis: A Document/Interaction-based UI for ODK

My Math Document

This is a sentence used to represent the interactivity between the text and the active document.

Interactivity.

Task 1

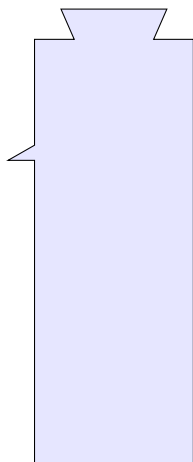
Task 2

Task 3

Task 4

Task 5

This is also interactive.



OpenDreamKit Notebook

