

Knowledge Mapping

An Application in Astronomy

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Overview

- Created a computer language to aid in documentation of astronomy observations
- Compiles into XML
 - Very extensible
- Insert resulting XML into a database for quick and easy searchability



Problem

- Compiler Design I & II with Dr. Randy Kaplan in Fall 2009
- Tasked with creating our own 'Little Language'
- Had to be useful when completed



Little Languages

- Abstract behaviors associated with programming
- Help programming to seem more mnemonic
- Limited function compared to a general purpose language



Building a Solution

- Uncertain as to what the capabilities of the result of compilation would be
- Knew what astronomy data I wanted to document
- Knew roughly what I wanted the code to look like
- Pretty good idea of the process for compiling high level code into machine code



Some Important Data to Document

- Equipment
 - All: Brand, Model Type
 - Telescopes: Aperture, Focal Length, Focal Ratio
 - Eyepieces: Field of View
- Observations
 - Weather, Wind, Seeing, Transparency, etc.
 - Location, Latitude/Longitude
 - Date/Time



Some Important Data to Document

- Targets
 - Proper name [Andromeda Galaxy]
 - Designation [Messier 31, NGC 224]
 - Magnitude [Brightness]
 - Celestial coordinates
- Images
 - Directory where located on disk
 - File Name



Language Structure

- Structurally sound programs of a language follow a given syntax.
- Syntax of a language is determined by its grammar
- Grammar implemented with a combination of lexical analysis and parsing



Lexical Analysis and Parsing



- Lexical Analysis builds tokens [Flex]
 - Sequences of characters defined by regular expressions
- Syntactical Analysis (Parsing) builds a tree structure using the tokens [Bison]
 - Representation of the syntactic structure of the language
 - Able to be processed into instructions



observation 2011/03/16

```
{
  time 22:34
  location "Kutztown, PA"
  latitude +14o22'55.0"N
  longitude +10o15'55.0"W
  weather "No clouds in the sky"
  transparency 3
  seeing 2
  temperature 72.0 c
  humidity 10.0%
  wind 0.5 mph ne

  target "Cats Eye Nebula" { designation ngc "6543" }

  target "Andromeda Galaxy"
  {
    type "galaxy"
    designation ngc "224"
    constellation "Andromeda"
    filter "Red"
    magnitude 5.5
    eyepiece 4 mm
    dir "~/Pictures/astrophotography/"
    {
      image "/andromeda/1.jpg"
      image "/andromeda/2.jpg"
      note "Accidentally shot in low quality"
    }
  }

  note "Light pollution was pretty bad"
}
```

Astronomy Observation Language

- Created a grammar that appears to be suitable for astronomy observations
- Created a compiler for the language using Lex/Bison
- What next?



Intermediate Code [Bytecode]

- Rather than compile directly to target machine code, generate bytecode
 - High level representation of instructions to be performed
 - Very portable
- Processed into machine code by:
 - Code Generator [Compilation Time]
 - Virtual Machine [Run Time]



Code Generation

- Created an arbitrary bytecode
 - Information rather than instructions
 - Retains all data acquired when building the parse tree
- Allowed for multiple target outputs
 - Separation of concerns
 - Comma Separated Values
 - HTML Tables
 - XML



XML

- Extensible Markup Language
- Structured method of storing data
- Tags are named in order to fit chosen data
- Easily read by Computer and Human
- Able to store metadata
- Many platforms have built in XML support



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    dir "~/Pictures/astrophotography/"
    {
      image "/andromeda/1.jpg"
      image "/andromeda/2.jpg"
      note "Accidentally shot in low quality"
    }
  }

  note "Light pollution was pretty bad"
}
```

```
<?xml version="1.0" encoding="UTF-8"?>
<AstronomyData>
  <Observation>
    <Date>
      <Year DataType="integer">
        2011
      </Year>
      <Month DataType="integer">
        3
      </Month>
      <Day DataType="integer">
        16
      </Day>
    </Date>
    <Time>
      <Hour DataType="integer">
        22
      </Hour>
      <Minute DataType="integer">
        34
      </Minute>
    </Time>
    <Location DataType="string">
      Kutztown, PA
    </Location>
    <Latitude Hemisphere="N">
      <Angle Type="sexagesimal" Sign="+">
        <Degrees DataType="integer">
          14
        </Degrees>
        <Minutes DataType="integer">
          22
        </Minutes>
        <Seconds DataType="double">
          55.000000
        </Seconds>
      </Angle>
    </Latitude>
```

```
<Longitude Hemisphere="W">
  <Angle Type="sexagesimal" Sign="+">
    <Degrees DataType="integer">
      10
    </Degrees>
    <Minutes DataType="integer">
      15
    </Minutes>
    <Seconds DataType="double">
      55.000000
    </Seconds>
  </Angle>
</Longitude>
<Weather DataType="string">
  No clouds in the sky
</Weather>
<Transparency DataType="integer">
  3
</Transparency>
<Seeing DataType="integer">
  2
</Seeing>
<Temperature DataType="double" Units="c">
  72.000000
</Temperature>
<Humidity DataType="double">
  10.000000
</Humidity>
<Wind DataType="integer" Units="mph" Direction="ne">
  0.500000
</Wind>
<Target>
  <ID DataType="string">
    Cats Eye Nebula
  </ID>
  <Designation>
    <Catalog DataType="string">
      ngc
    </Catalog>
```

XML Processing

- What to do with XML data?
- Process with XSLT
 - Extensible Stylesheet Language Transformations
 - Generates a formatted HTML page
- Parse and revalidate the XML using one of many languages with XML support

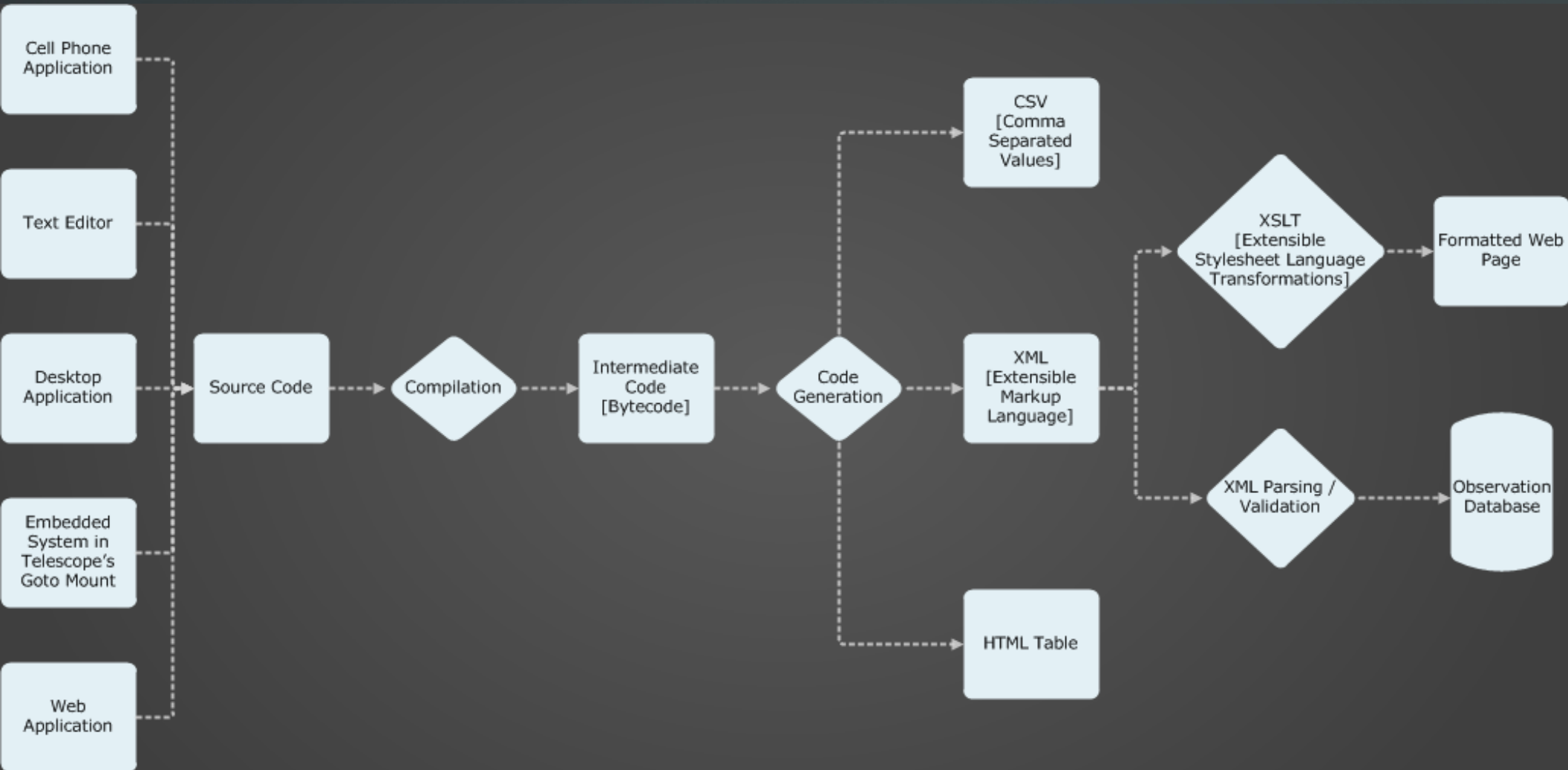


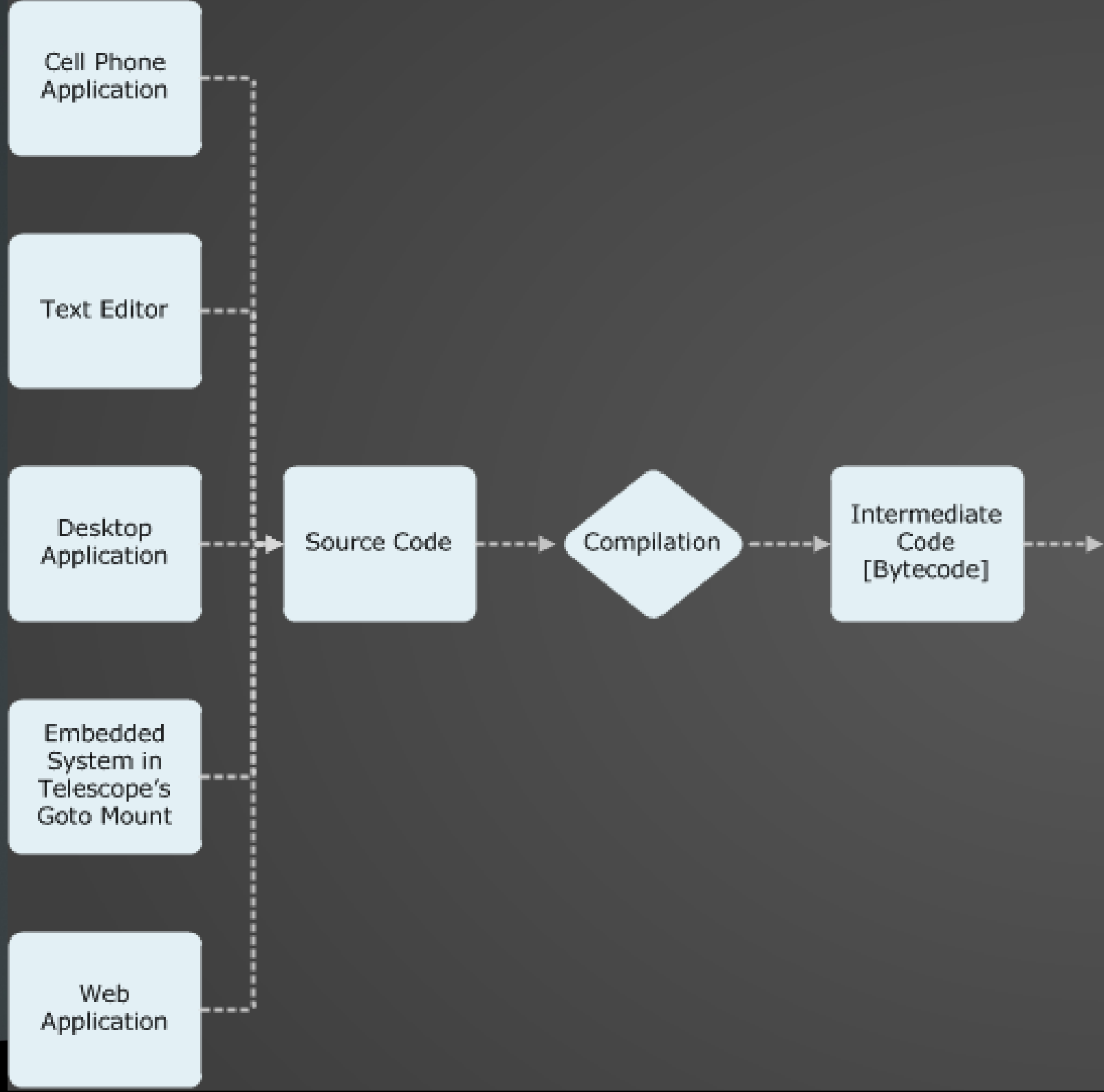
Use a Database

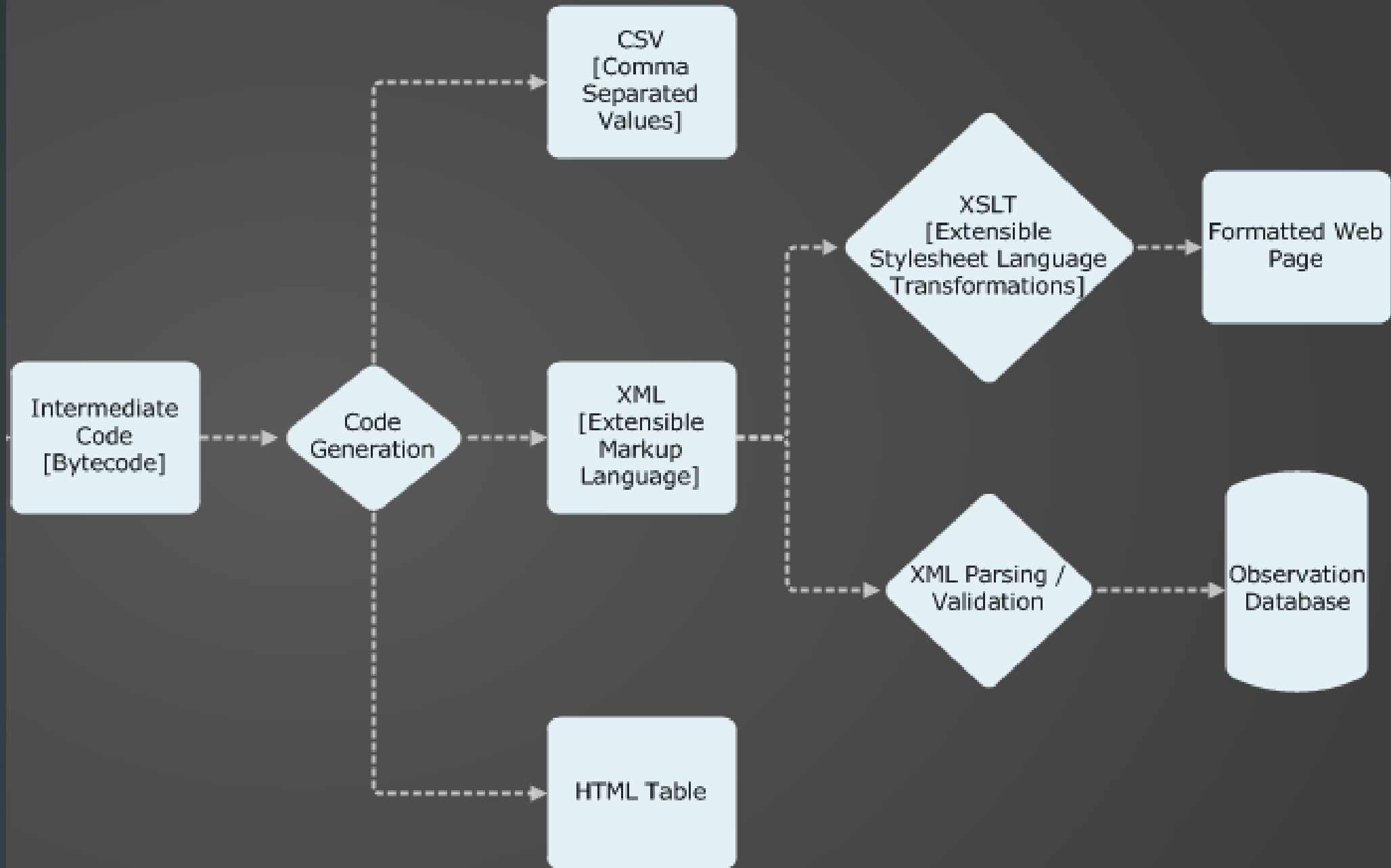
- Parse the information into respective data structures
 - Chose to use PHP
- Format information and insert into database
 - Chose to use MySQL
 - Error checking/datatype validation!
 - `mysql_real_escape_string()!!!`



Process Overview







Database Utilization

- Share observation data with other astronomers online
- Retrieve data based on given set of parameters:
 - All observations by user X in Kutztown, PA
 - Observations by any user where Jupiter was a target
- Attempt to identify sky objects by available information:
 - Identify any stars in constellation Leo with -1.0 magnitude and spectral type of G2



Further Development

- Expand documentation capabilities
- Programs to make source code generation more convenient
 - Complete web interface
 - Java?
 - Integrate into GoTo mount?
- Make process seamless as possible



Goals

- Make documentation and sharing of observations easier for the user
 - Capable of documenting enough?
 - Refactor as necessary
- Make generation and processing of observation data easier for the computer
 - Many to many relationship



Questions?



”We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology.”

- Carl Sagan

