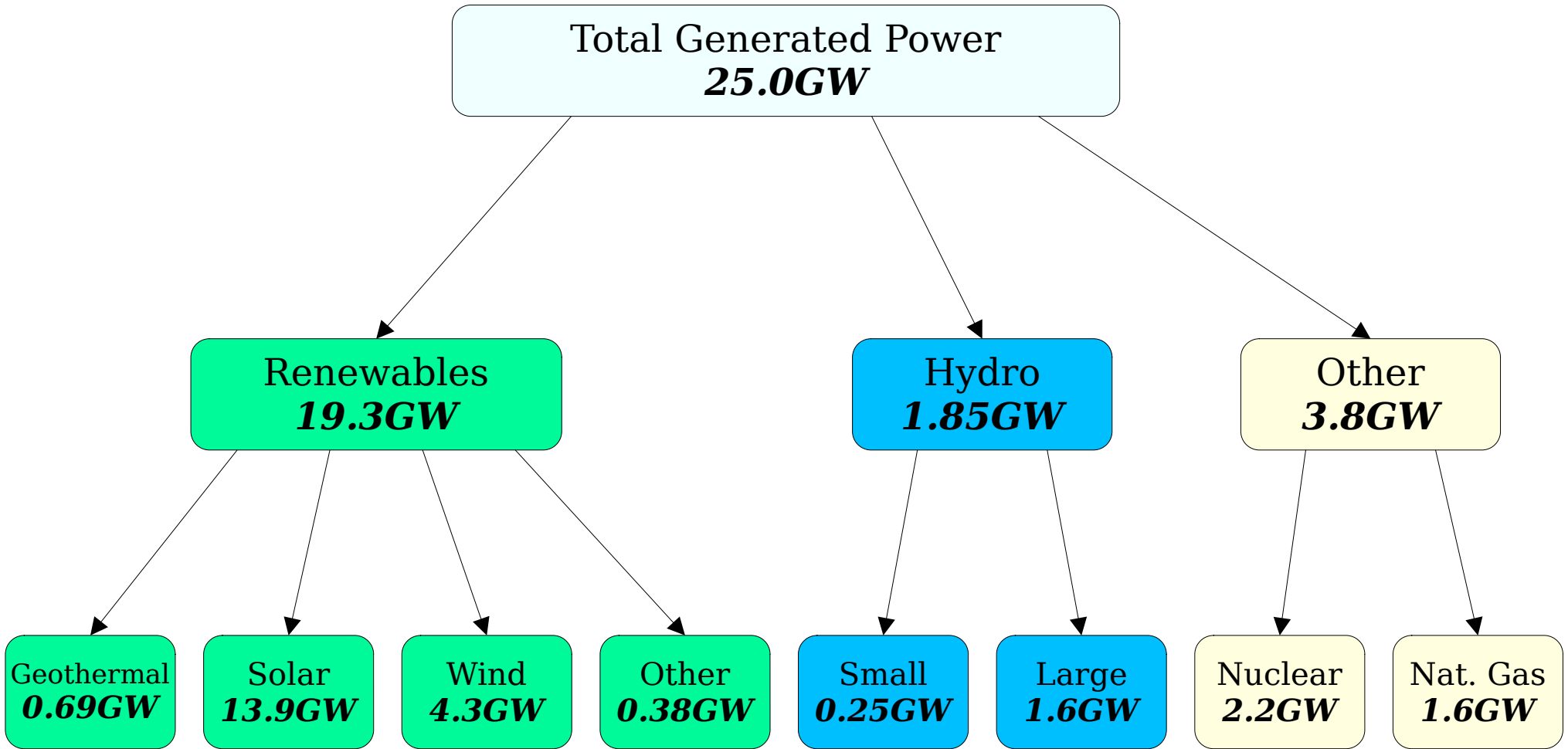


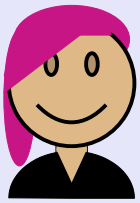
Multiway Trees

Outline for Today

- ***Multiway Trees***
 - Expanding our tree possibilities.
- ***Representing Multiway Trees***
 - Modeling branching in software.
- ***Working With Real-World Data***
 - JSON and public data sets.



*Electric Power Generation in California, March 2, 2025, 8:20AM
Source: California Independent System Operator (CAISO)*



Article: The Numbers Aren't As Bad As They Look

Like many of you, I was initially surprised when I read headlines today detailing recent national trends. However, when you look more closely ...



This was a fascinating article. I had a different interpretation of the data from the report. In particular, this could also be ...



I hadn't considered that. Thank you for providing that thoughtful perspective. It shows how nuanced ...



Refining your argument: the concerning increase in the trends identified here may also be caused by ...



You're absolutely right. I hadn't thought of things that way. Thanks for pointing ...



Your alternate explanation has led me to think more critically about this issue and understand why ...



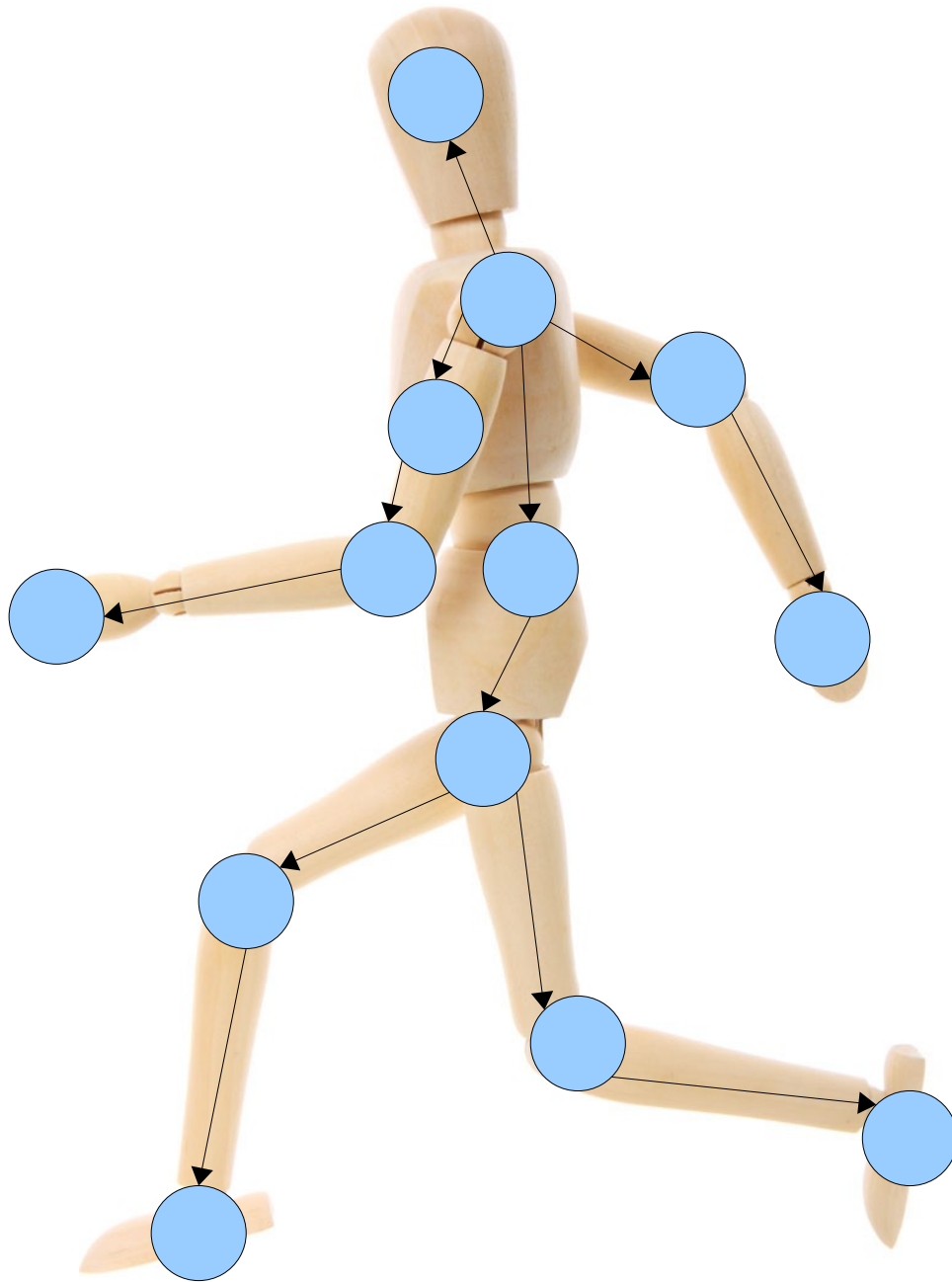
Thank you for taking the time to really investigate the data, rather than simply repeating a simple explanation for how ...



The data that you are sharing here are indeed taken from that agency, but it's still a preliminary report. Does that change ...

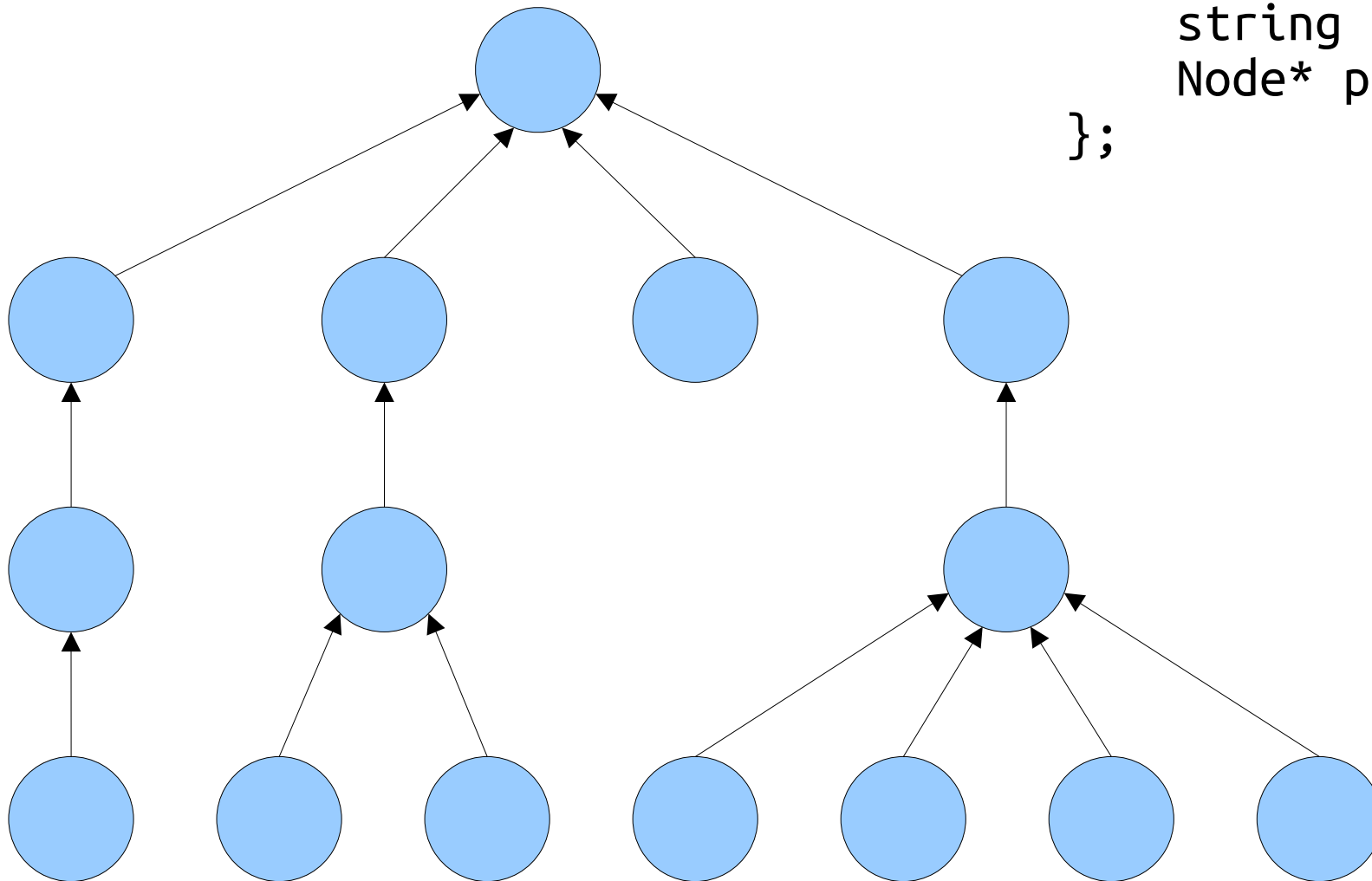


You're right to identify this. Historically, the initial reports have not changed substantially when the ...



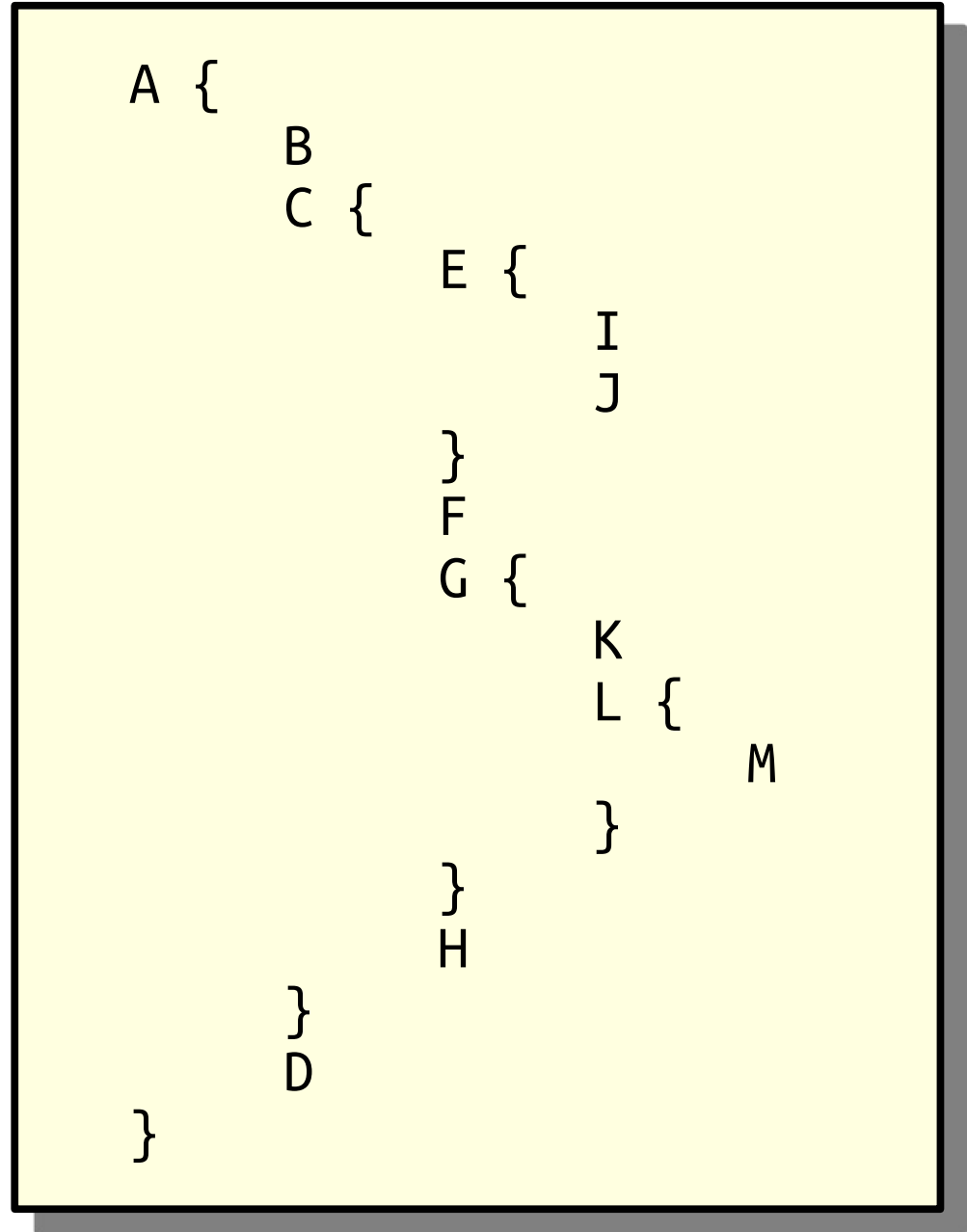
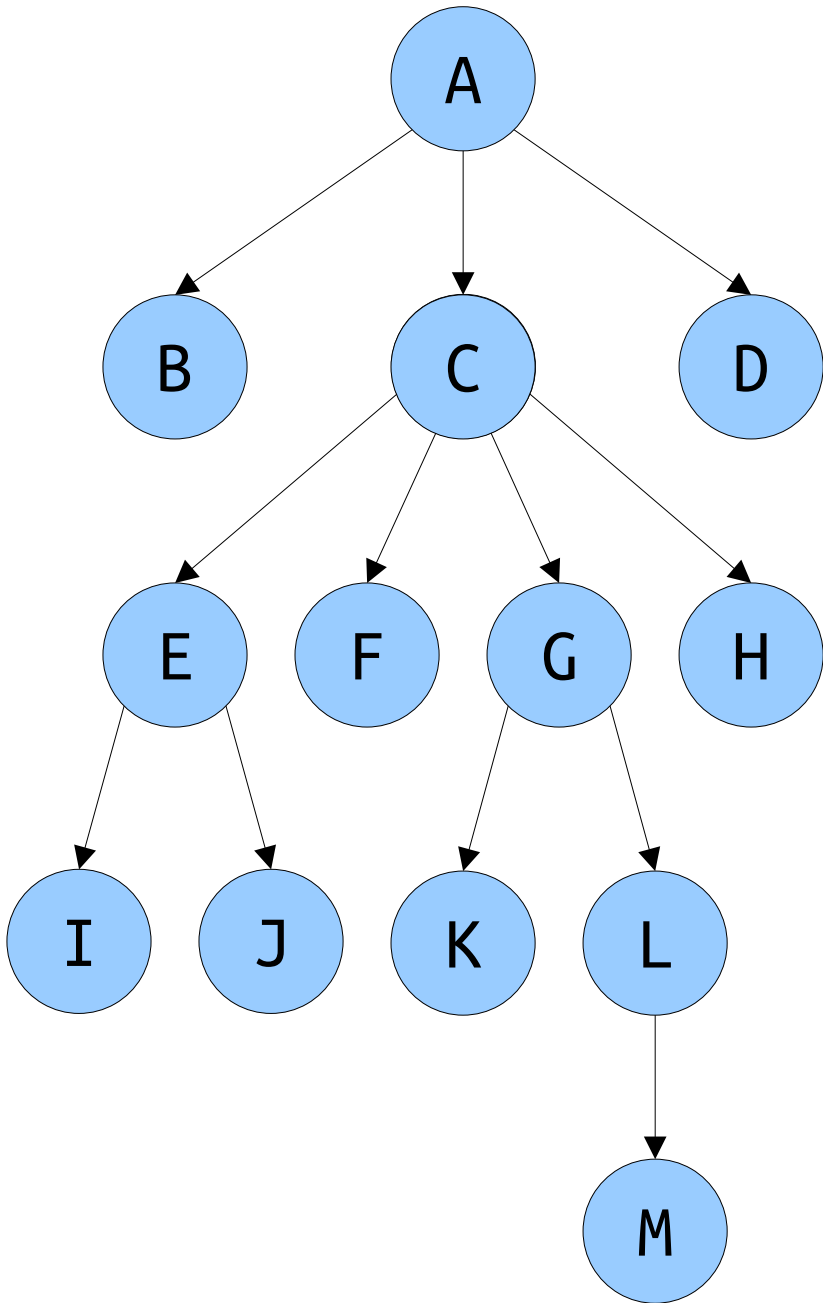
Representing Multiway Trees

An Alternative Approach



```
struct Node {  
    string data;  
    Node* parent;  
};
```


Working with Multiway Trees



Working with Real-World Data Sets

Getting Data

- Many organizations (governments, nonprofits, companies, etc.) release huge quantities of data to the public.
- You have enough coding background at this point to write programs that manipulate, analyze, and visualize these data sets.
 - Often times, you'll need to write more code to get data into your program than you will write to analyze it!
- There are multiple different data file formats out there, of which a few are used frequently when data are released to the public.

JSON

- **JSON** (JavaScript Object Notation) is a popular format for exporting structured data.
- You can find all sorts of JSON data sets out there. For example...
 - The US Geological Survey publishes information on [all recent earthquakes](#) via JSON.
 - The National Park Service lets you query for [information](#) about parks, activities, closures, etc. and get the result in JSON.
- Let's briefly explore how JSON works.

```
["Hi Mom!", 2.71828, 137, [true, false, true]]
```

JSON can store arrays of values of mixed types.

```
{ "bear":      ["grizzly", "polar", "black", "sun"],  
  "cat":      ["bob", "house", "savannah"],  
  "hummingbird": ["bee", "topaz", "Anna's"] }
```

JSON can encode “objects,” akin to our Map type.

JSON in C++

- We've provided a JSON type that stores JSON data.
- You can create a JSON object from a string or a stream:

```
JSON str = JSON::parse("[1, 2, 3]");  
JSON file = JSON::parse(input);
```

- You can check the type of JSON data and get a view of that data as that type:

```
if (json.type() == JSON::Type::NUMBER) {  
    cout << json.asInteger() << endl;  
}
```

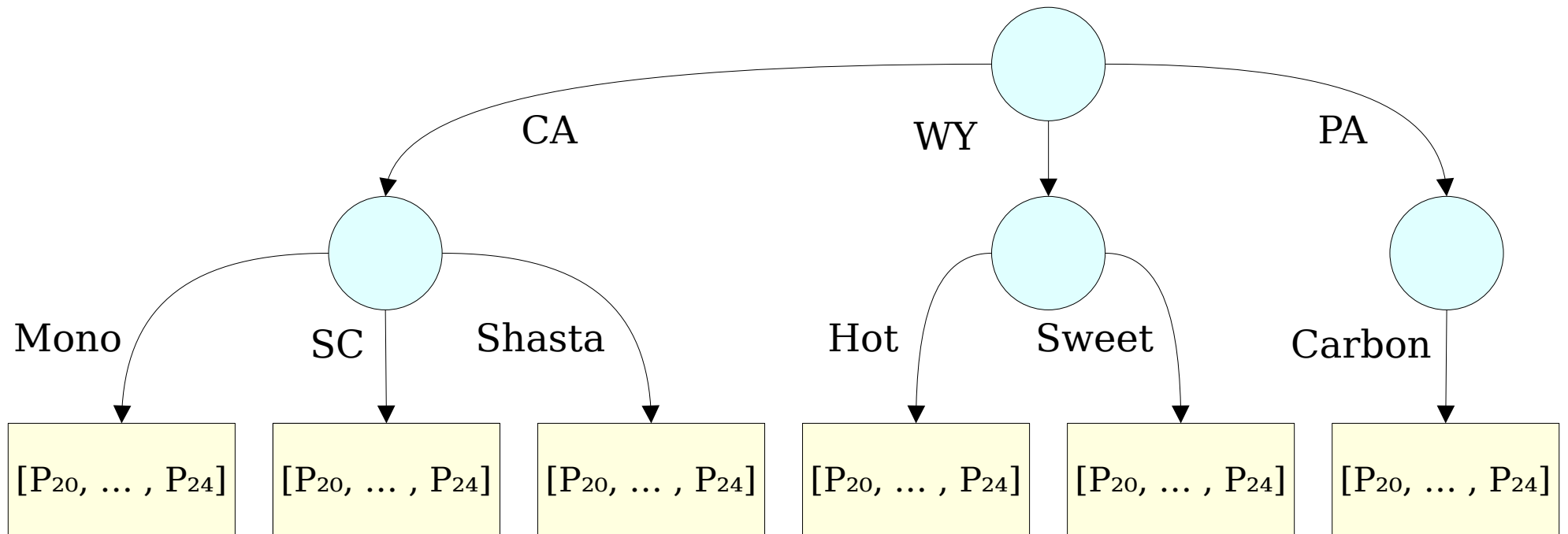
- You can look up elements by index (arrays) or key (objects):

```
JSON first = json[0];  
JSON cute = json["quokka"];
```


Our Data Set

- The US Census Bureau *provides* information on the population of every US county over the past five years.
- I've downloaded this data and converted it into a JSON file.
- ***Our Goal:*** Determine the population of the US in each of the past five years.
 - (We can do a lot more elaborate processing than this; the goal here is to show off the concept.)
- Let's see what data we have.

```
{
  "California": {
    "Mono County": [ 13201, 13228, 13271, 13002, 13066],
    "Santa Clara County": [1936279, 1931168, 1885173, 1878335, 1877592],
    "Shasta County": [ 182158, 182002, 182135, 180937, 180366],
  },
  "Wyoming": {
    "Hot Springs County": [ 4619, 4621, 4595, 4623, 4661],
    "Sweetwater County": [ 42271, 42197, 41626, 41374, 41249],
  },
  "Pennsylvania": {
    "Carbon County": [ 64753, 64752, 65522, 65493, 65458],
  }
}
```



Your Action Items

- ***Finish Assignment 7***
 - If you're following our timeline, you'll have finished the debugger warmup and doubly-linked-list warmups by now, and will have made some progress on Particle Systems.
 - Aim to complete Particle Systems by Friday.
 - Reminder: You can't use late days on Assignment 8. Be strategic about using them on Assignment 7.