Back-end DB / OpenDB

Date: April 2, 2026

Matt Liberty
Precision Innovations

Thanks to Prof. Austin Rovinski, NYU
https://www.youtube.com/@AustinRovinskiNYU/playlists

Who Am I?

- I have worked for 30 years in EDA at
  - Cadence, Synopsys, Intel (µP & FPGA), Altera, Coverity, various startups
- Currently VP of Engineering for Precision Innovations
  - The company behind the development of OpenROAD

- I am a generalist who has worked on many backend tools for:
  - Electrical analysis: circuit simulation, static timing, and RC extraction
  - Physical design: placement, routing, manufacturability, etc
  - Infrastructure: GUI, databases
  - Software development: static code analysis, CI, coding methodology, etc
- I'm located in Santa Barbara, CA

What is OpenROAD

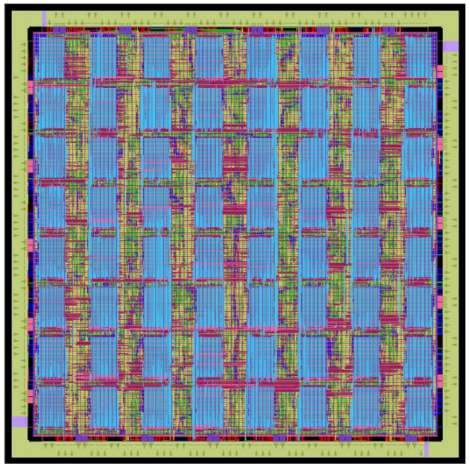
- **Fully Open-Source Place-and-Route tool for digital logic design.**
  - **Contains OpenDB as key infrastructure.**

- **The Application**
  - **https://github.com/The-OpenROAD-Project/OpenROAD**

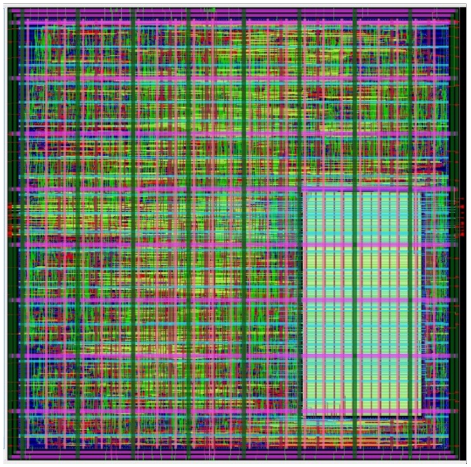
- **The RTL-to-GDS Flow:**
  - **https://github.com/The-OpenROAD-Project/OpenROAD-flow-scripts**

- **Flow Tutorial**
  - **https://openroad-flow-scripts.readthedocs.io/en/latest/tutorials/FlowTutorial.html**

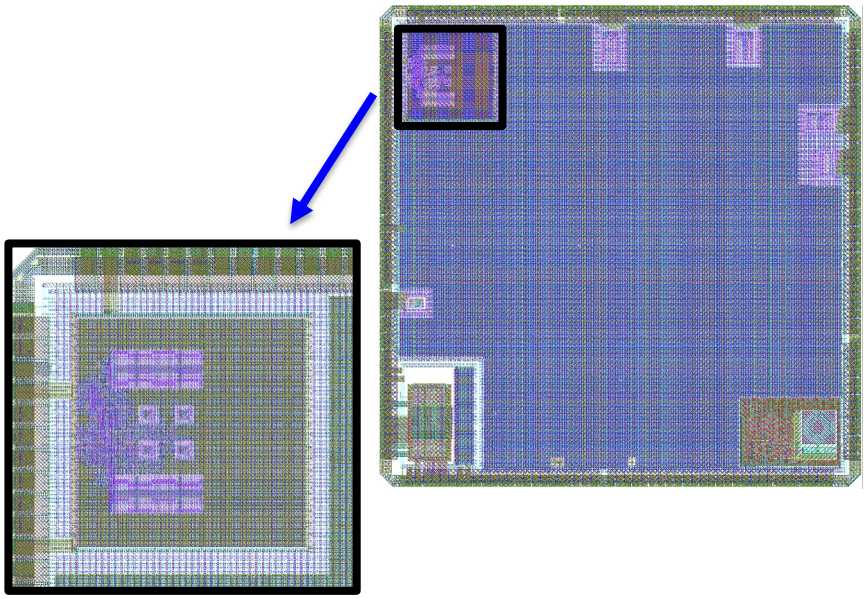
OpenROAD Usage



GF55 AI platform



GF12LP AI tile



OpenTitan SoC

Army Research Labs
GF55, GF12LP

U. Michigan / FASoC
GF12LP

Credit: Prof. Kahng

What is the front-end / back-end?

Front-end

Behavioral description

Boolean

Protocols

Functional verification

Linting / assertion

Test coverage

Back-end

Structural description

Physical / Spatial

Electrical :

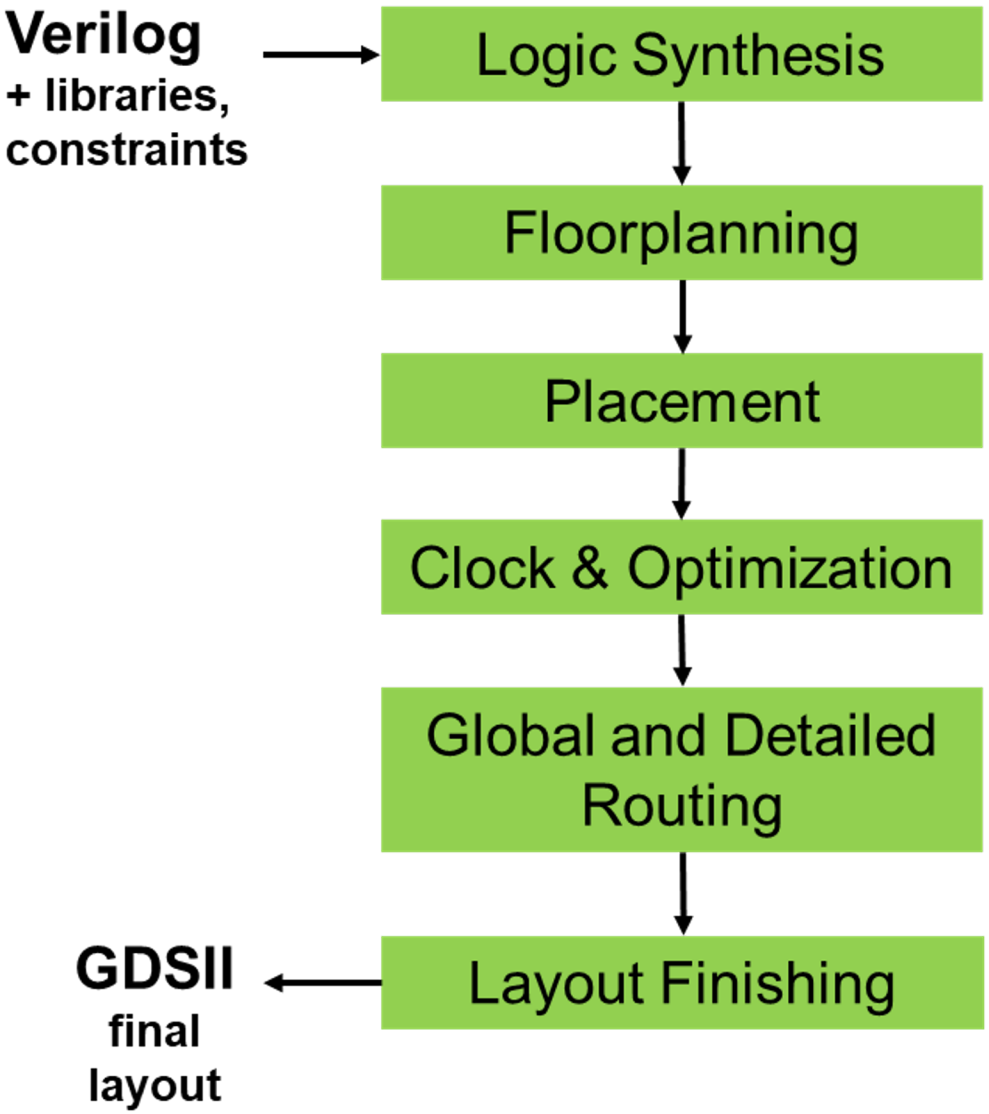
- Timing
- Power consumption
- Thermal

Power distribution

Yield / Manufacturability

Reliability

OpenROAD steps



Logic synthesis is the bridge between front & back end:

Behavior in

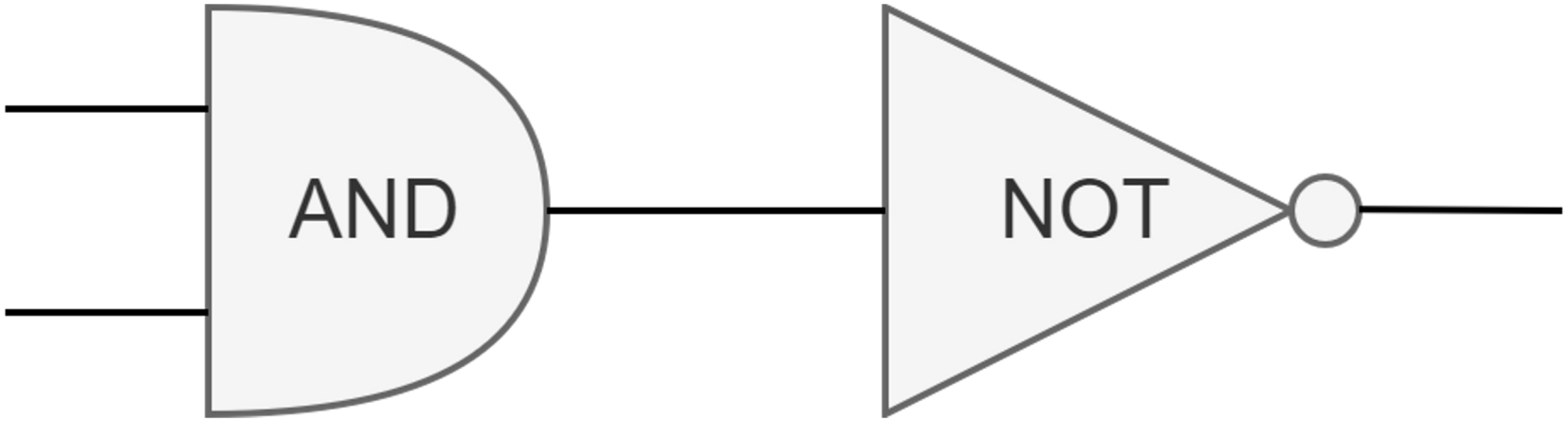
Structure out

Uses a common database throughout

What is a back-end DB?

- Not an off the shelf database
- Not SQL nor NO-SQL! No query language at all!
- Custom built for EDA applications and present an object oriented interface.
- Typically written in C++
- OpenDB is an open-source EDA database used in OpenROAD.
- Open Access is an industry consortium database

Example Circuit



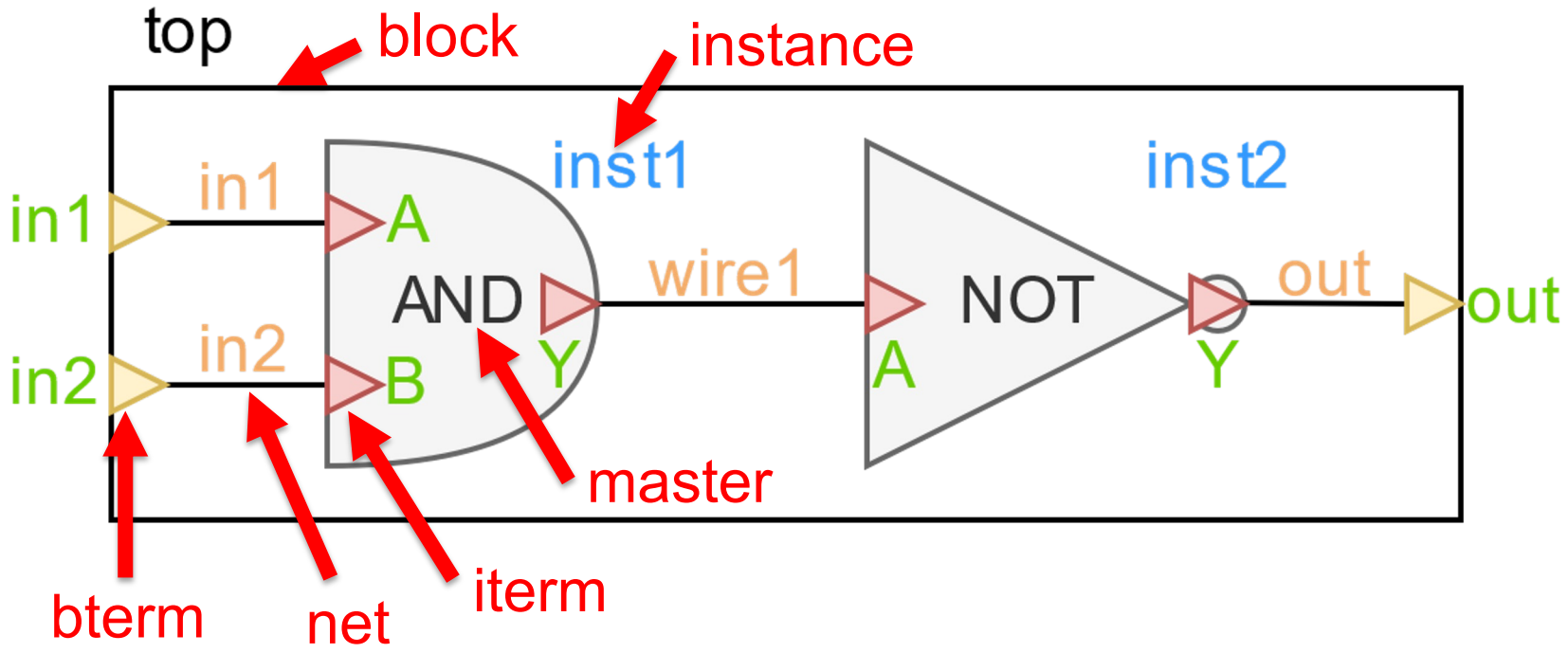
Example Circuit: Structural Verilog

```
module top(
   input wire in1,
   input wire in2,
   output wire out
);
   wire wire1;
   AND inst1 (.A(in1), .B(in2), .Y(wire1));
   NOT inst2 (.A(wire1), .Y(out));
endmodule
```

Behavioral: `assign out = ~(in1 & in2);`

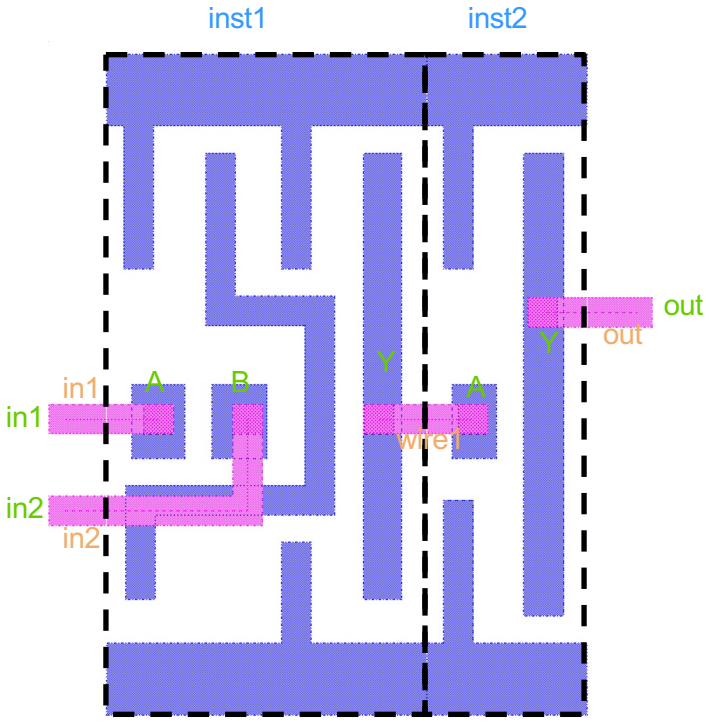
Could also be implemented with a nand2

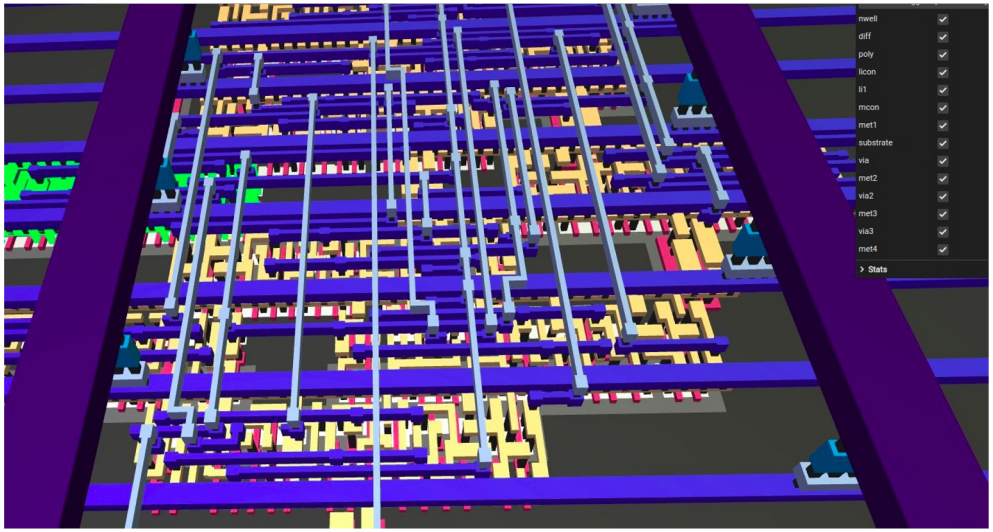
Example Circuit: Detailed Logical View



OpenDB Terminology

Example Circuit: Physical View





5-Box Model

- Every structural netlist has five components but various databases and file formats name them differently.

1. Block: Module, Cell
2. Net
3. Instance: Inst, SRef
4. BTerm : Pin, Port, Term
5. ITerm : InstTerm, InstPort, PortRef, Pin, Port, Term

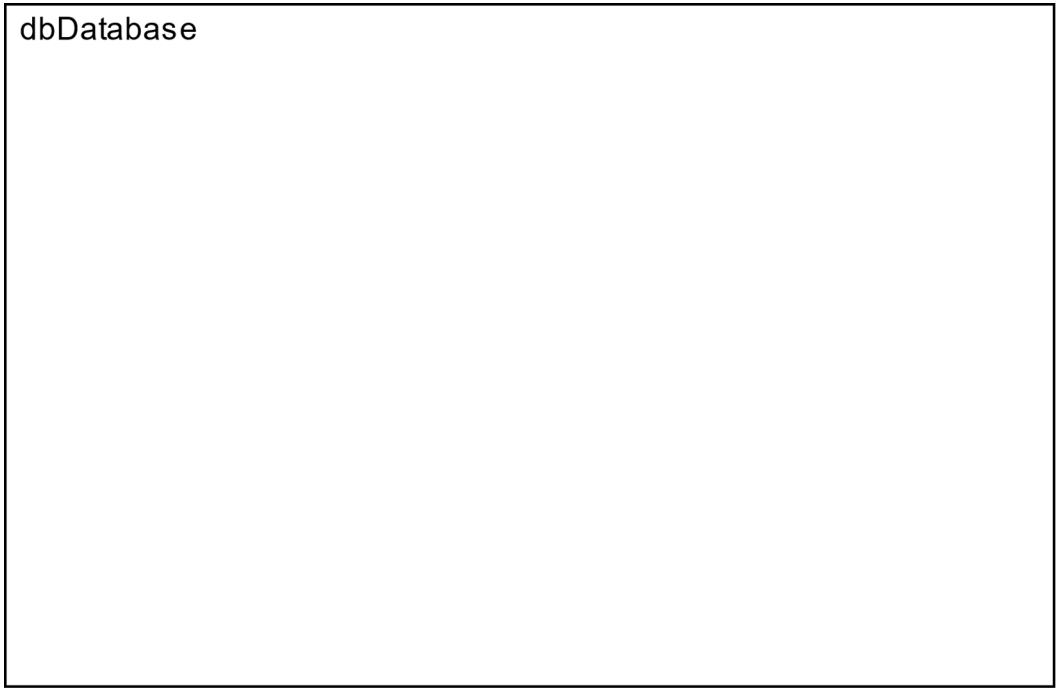
- Pin / Port / Term are horribly overloaded and conflicting across different DBs.

5-Box Add-ons

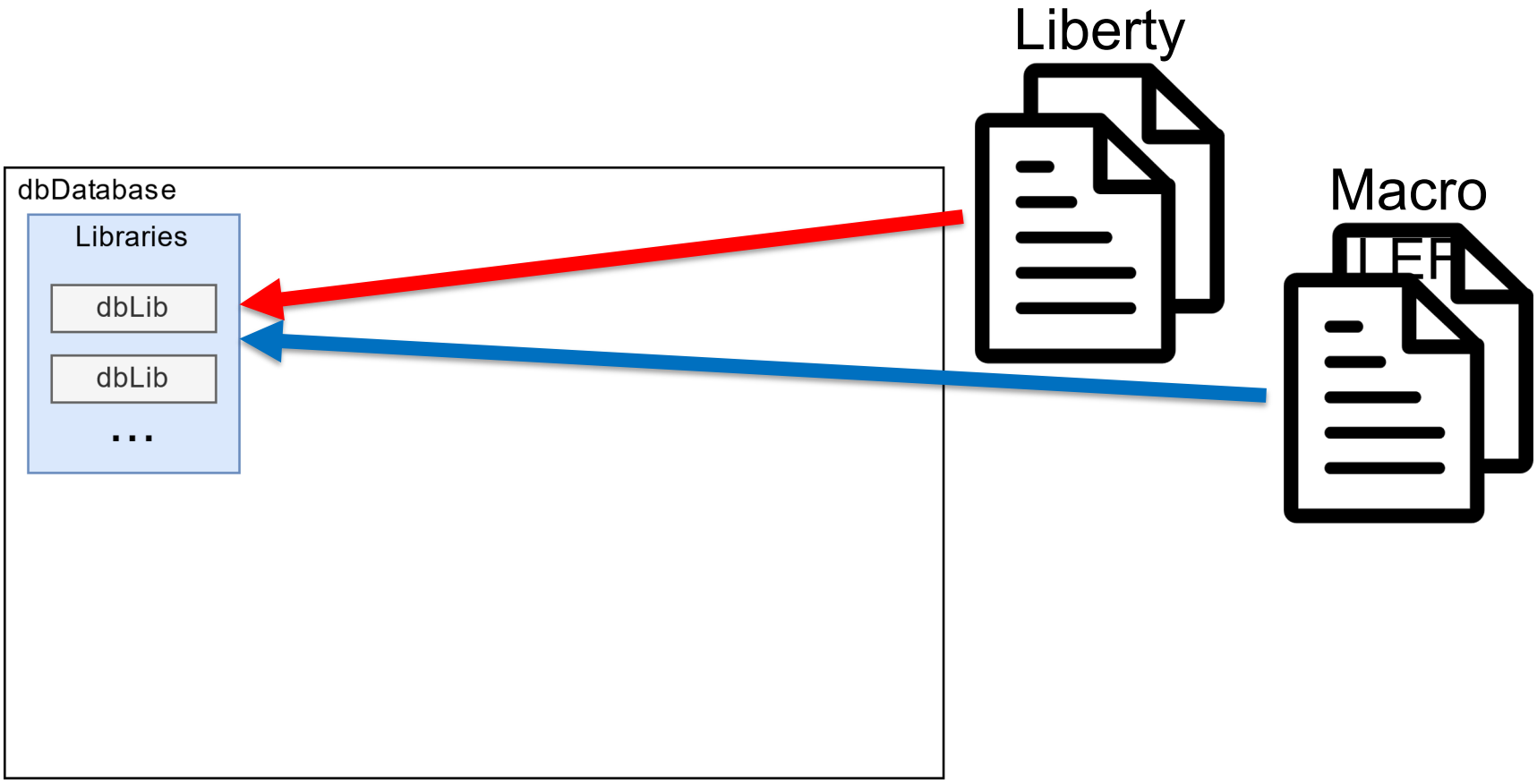
- The 5-box model defines scalar connectivity (single-bits). Additional object may represent:

- An arrays of instances
- A net bus (eg a[5:0]) or terminal bus
- A net group ({a, b, z})
- A common base class for BTerm and ITerm

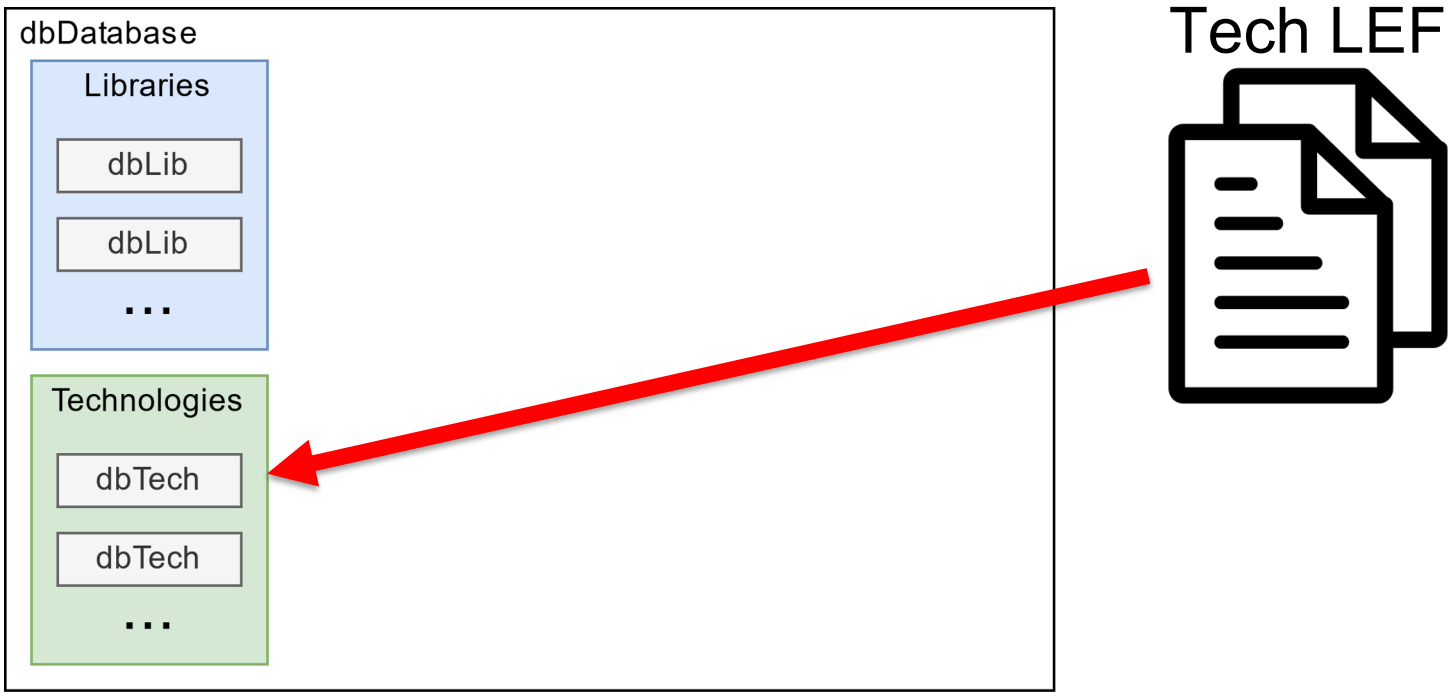
OpenDB: Top-Down View



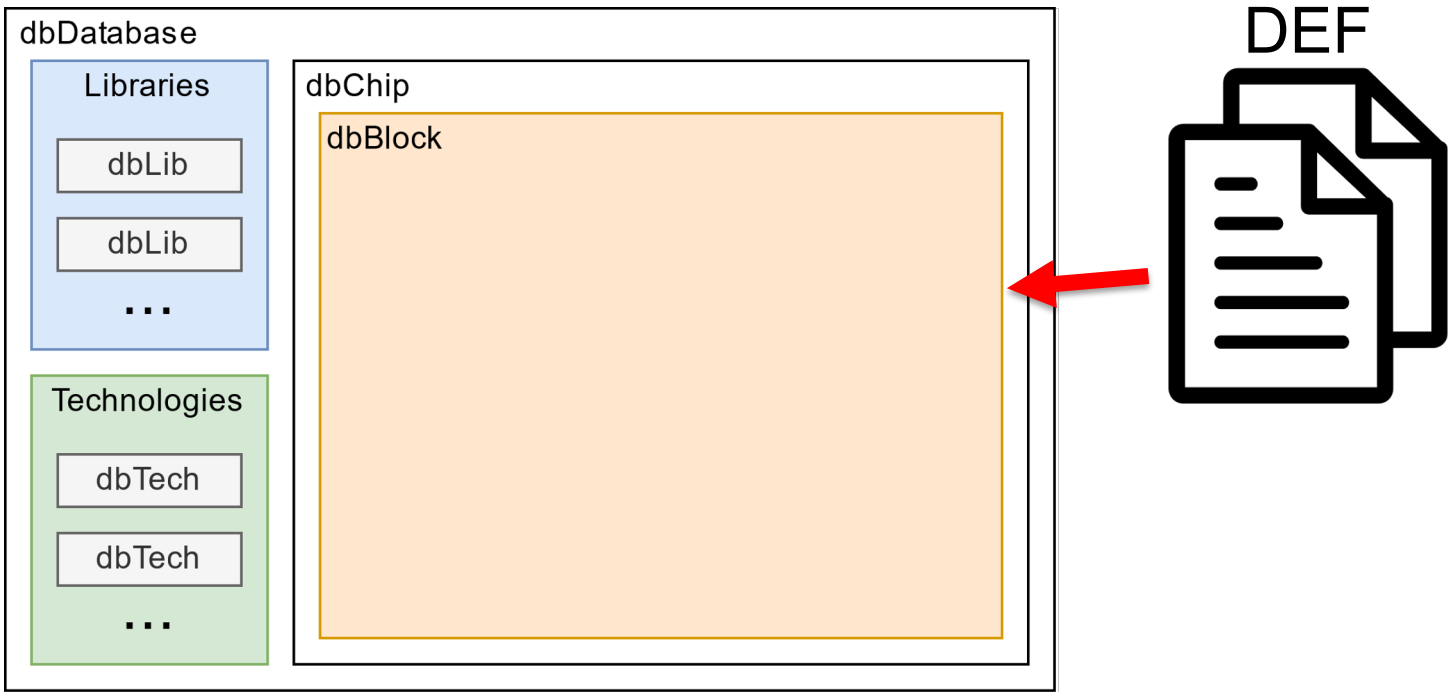
OpenDB: Top-Down View



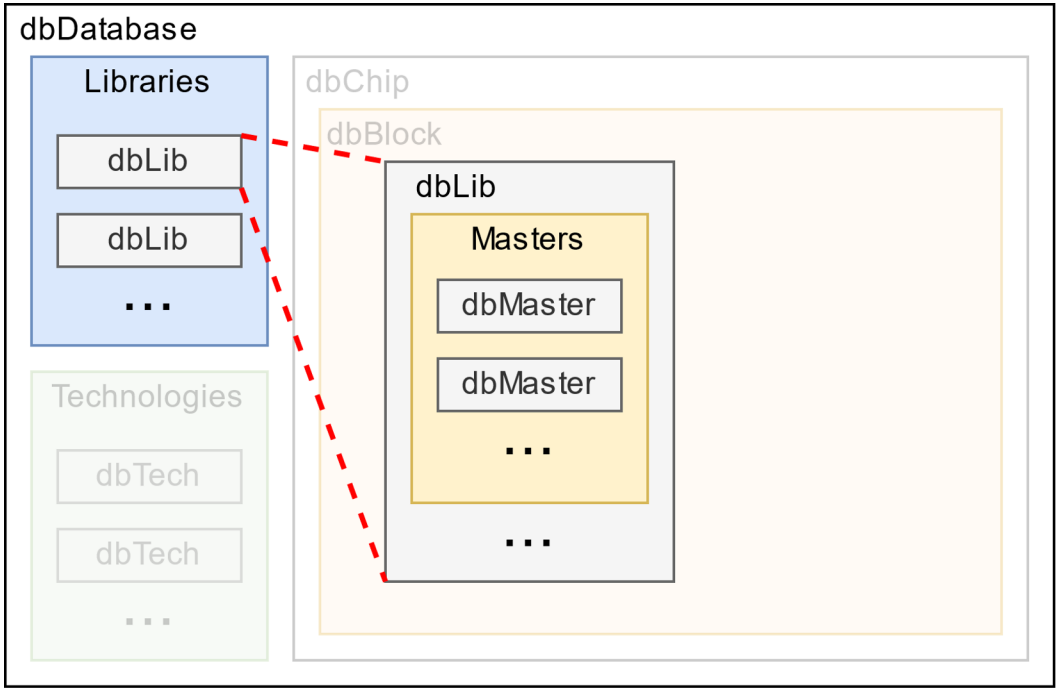
OpenDB: Top-Down View



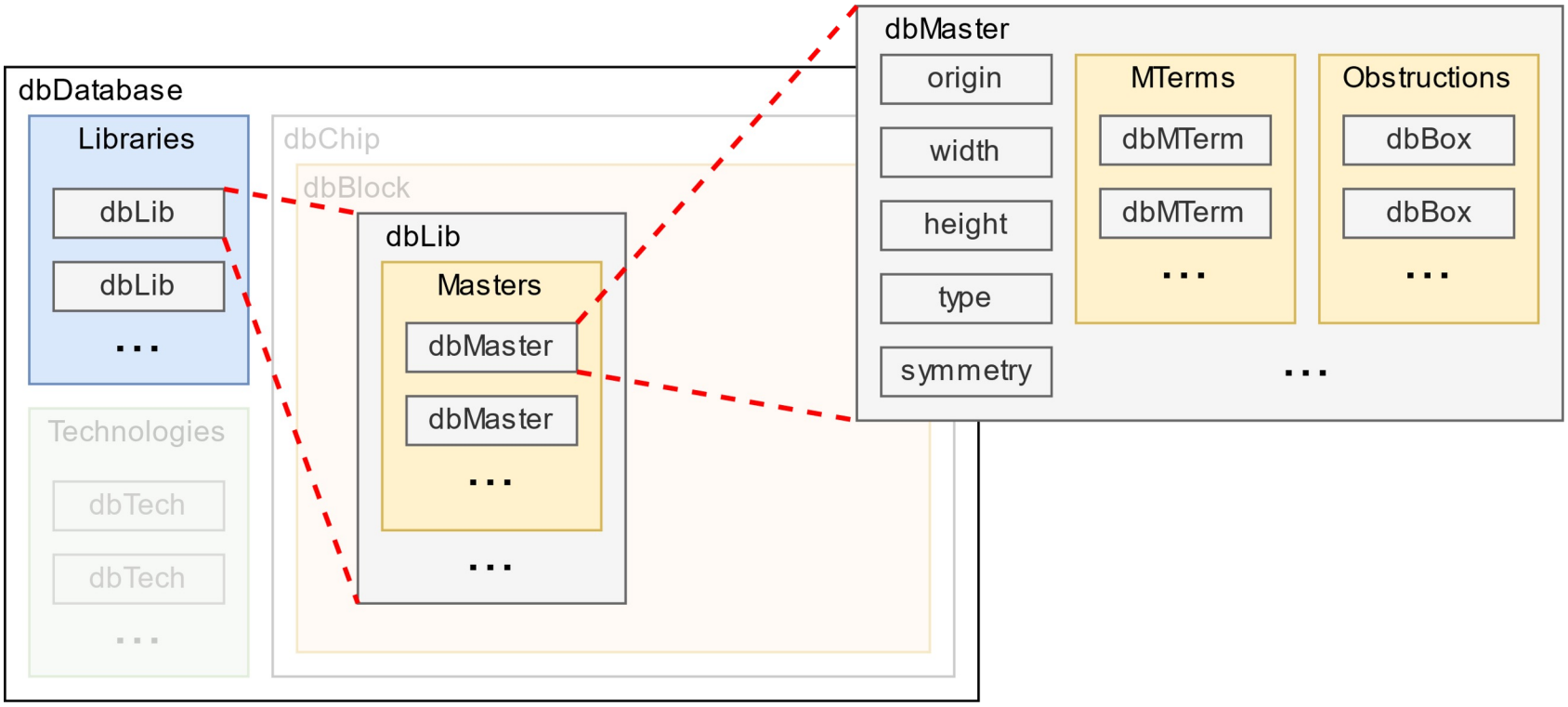
OpenDB: Top-Down View



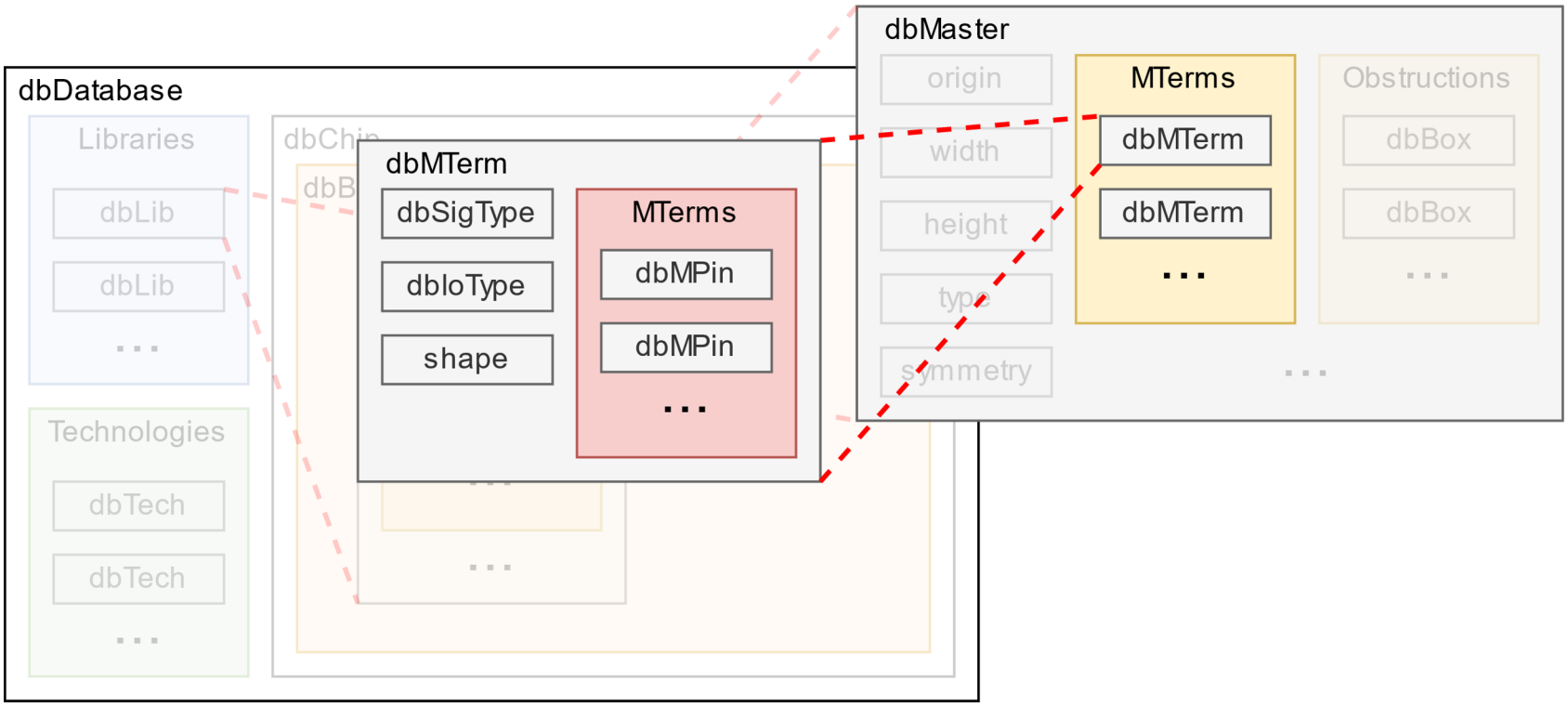
dbLib Class


dbDatabase
Libraries
dbLib
dbLib
...
Technologies
dbTech
dbTech
...
dbChip
dbBlock
dbLib
Masters
dbMaster
dbMaster
...
...

dbMaster class

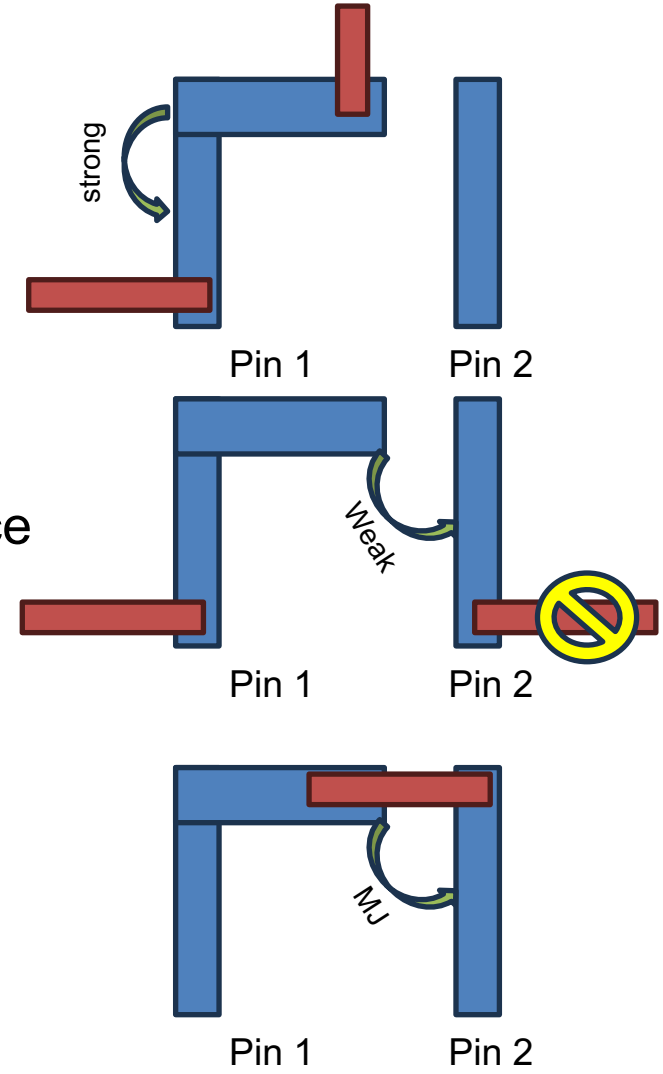


dbMTerm class

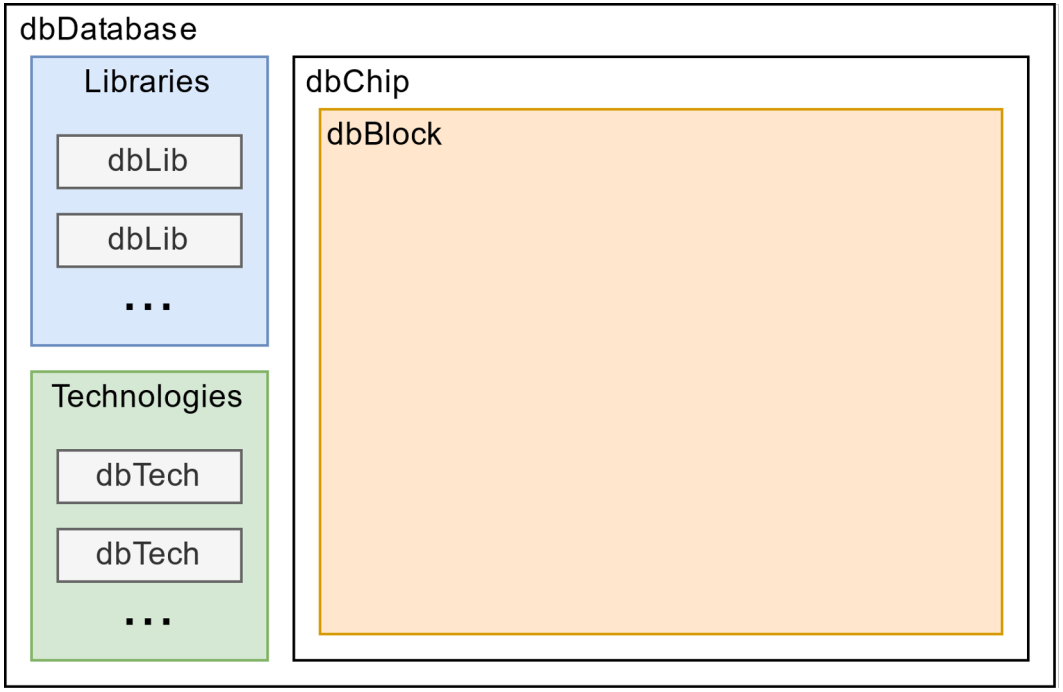


Physical Pin Models

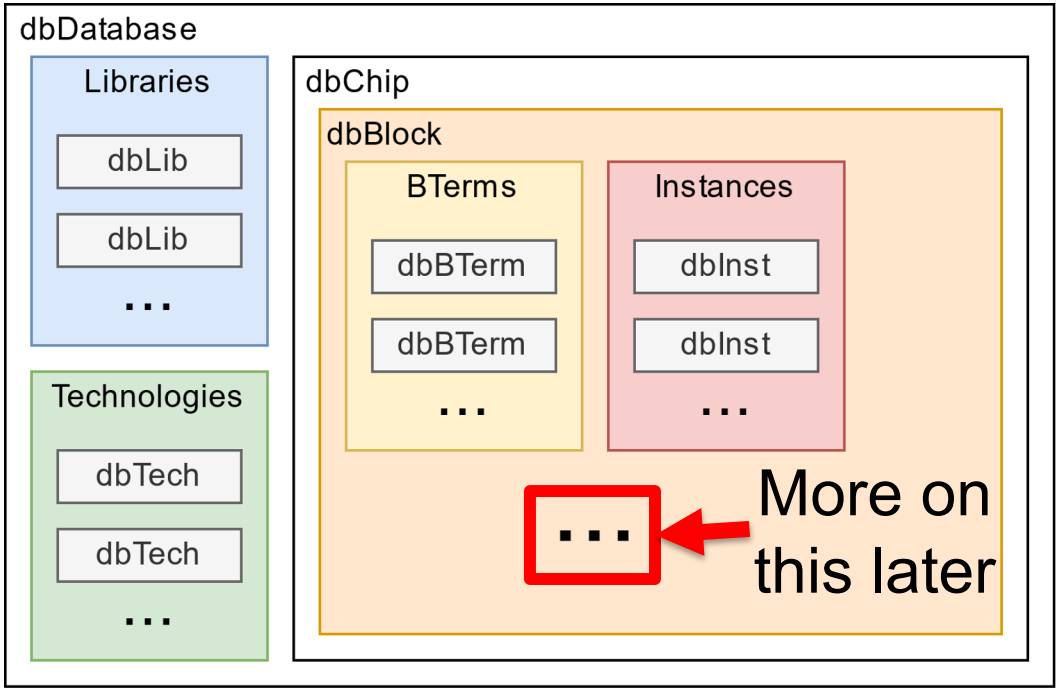
- Strong connect (99.9%)
  - Shapes within a single dbMPin
  - Form a single piece of metal.
- Weak connect
  - Different dbMPin within a single dbMTerm
  - They are connected by a high resistance internal connection (e.g. poly)
- Must Join
  - Different dbMPin within a single dbMTerm *specially marked*
  - No internal connection, the router must connect these pins externally to the instance
  - Not commonly used.
  - Hard to characterize such a cell.



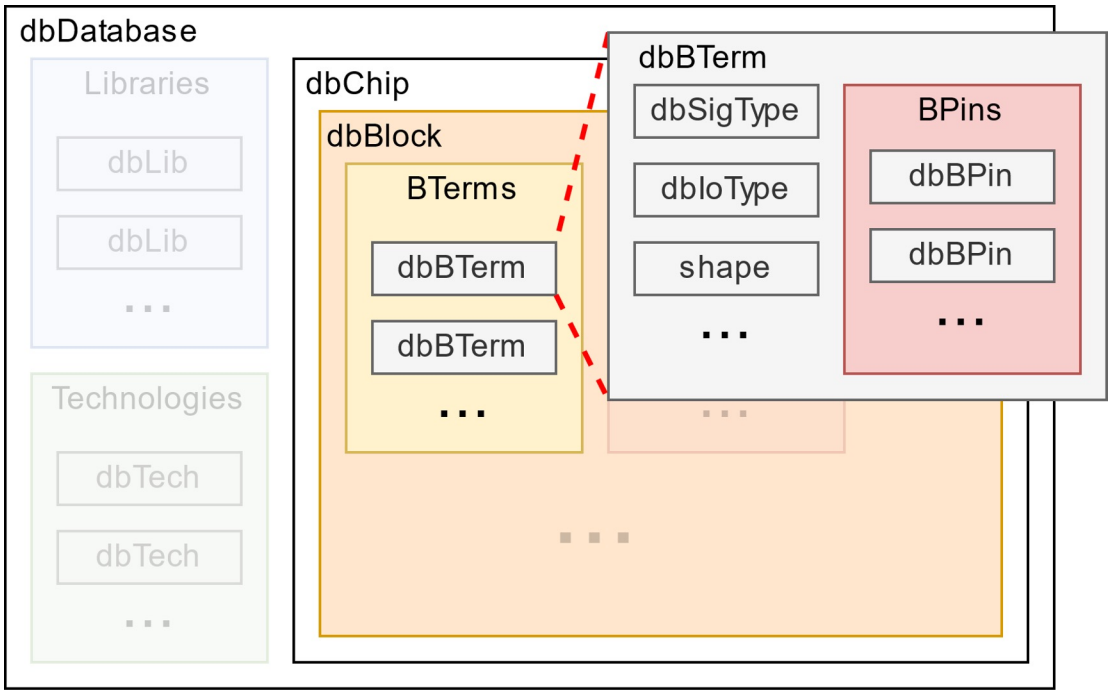
OpenDB: Top-Down View



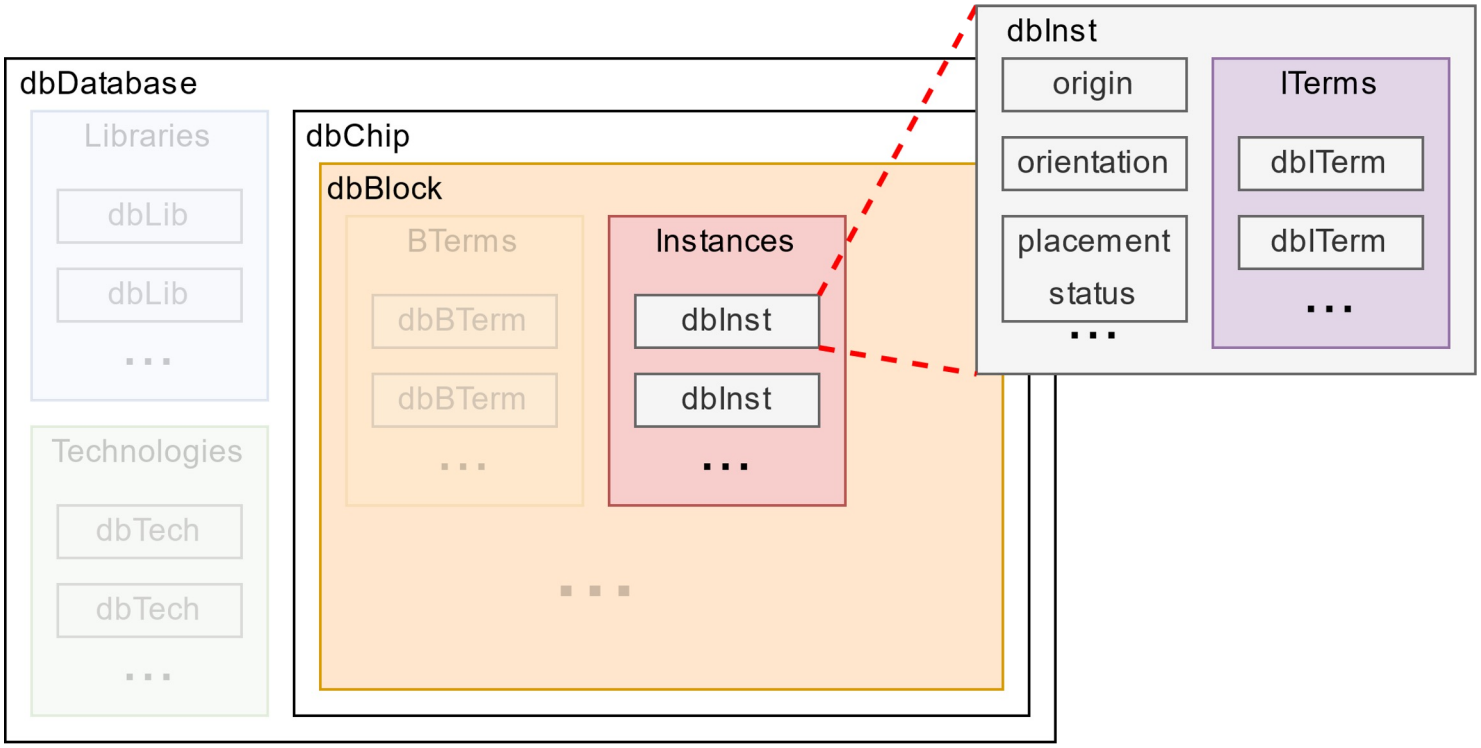
dbBlock Class



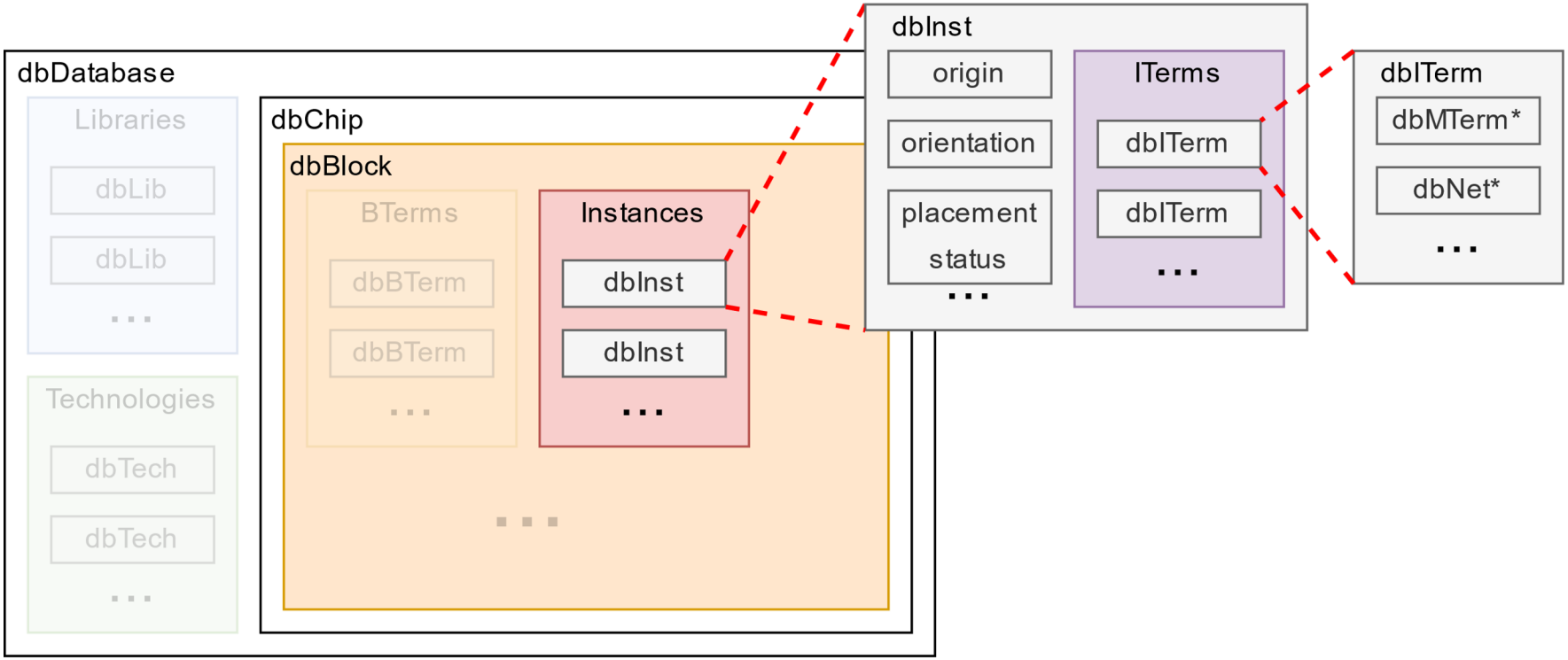
dbBTerm Class



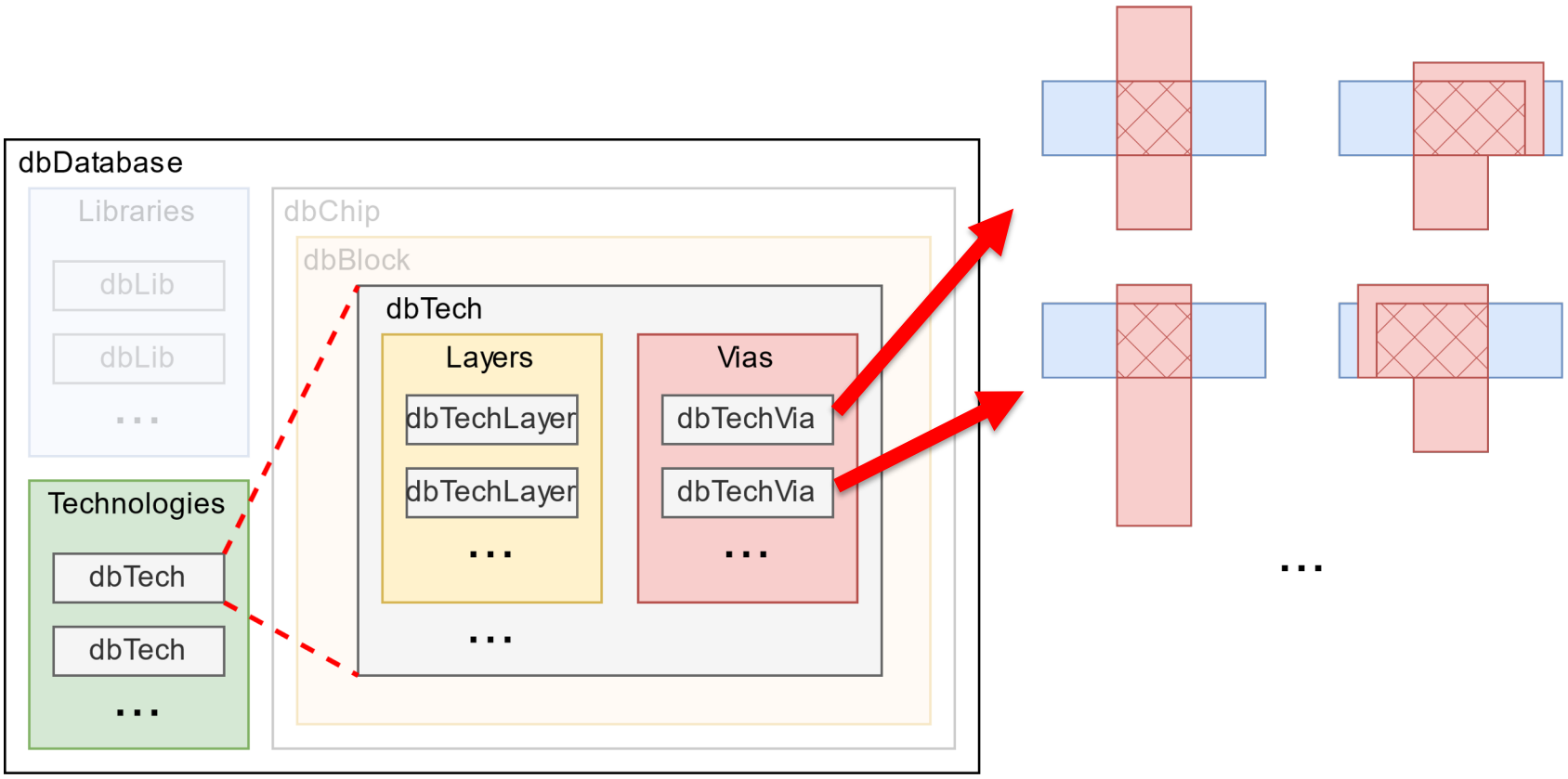
dbInst Class



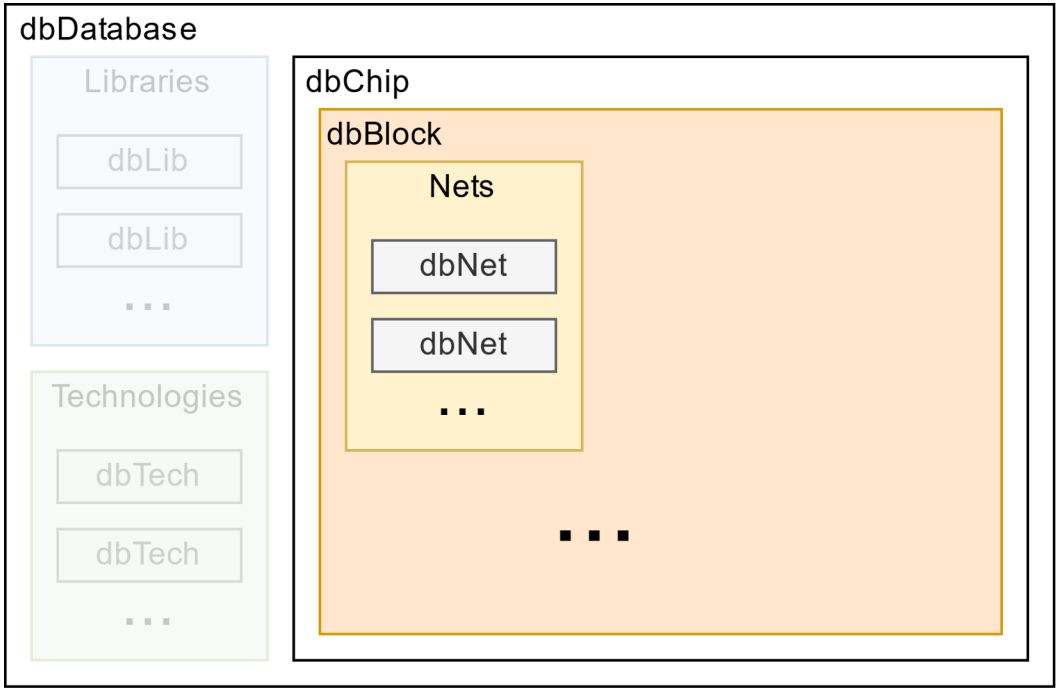
dbITerm Class



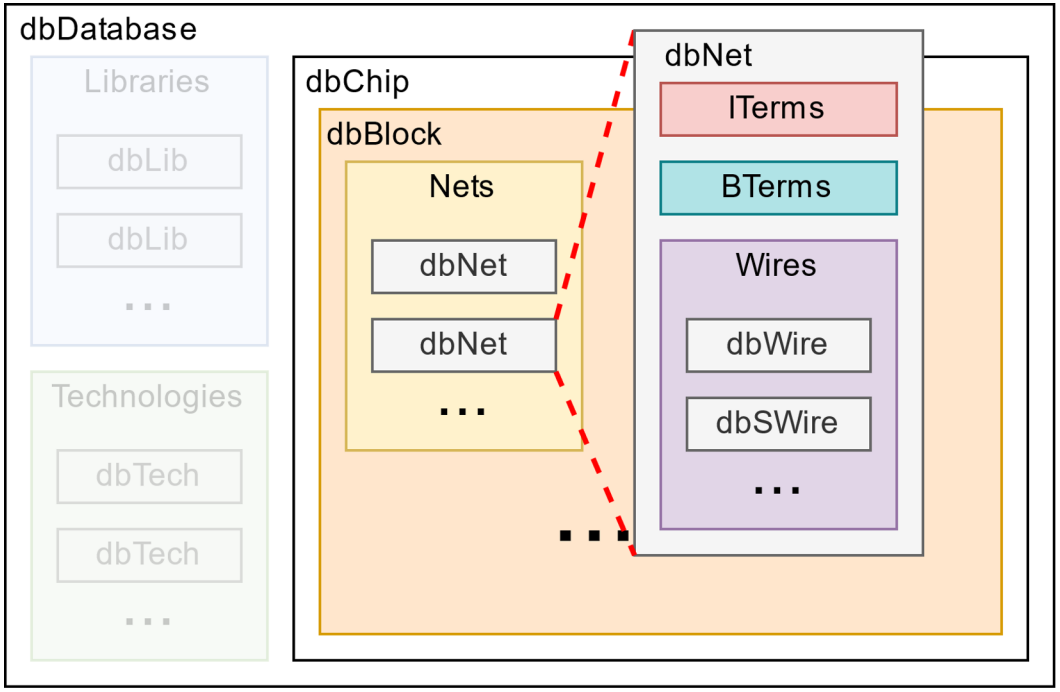
dbTech


dbDatabase
Libraries
dbLib
dbLib
...
Technologies
dbTech
dbTech
...
dbChip
dbBlock
dbTech
Layers
dbTechLayer
dbTechLayer
...
Vias
dbTechVia
dbTechVia
...
...
...

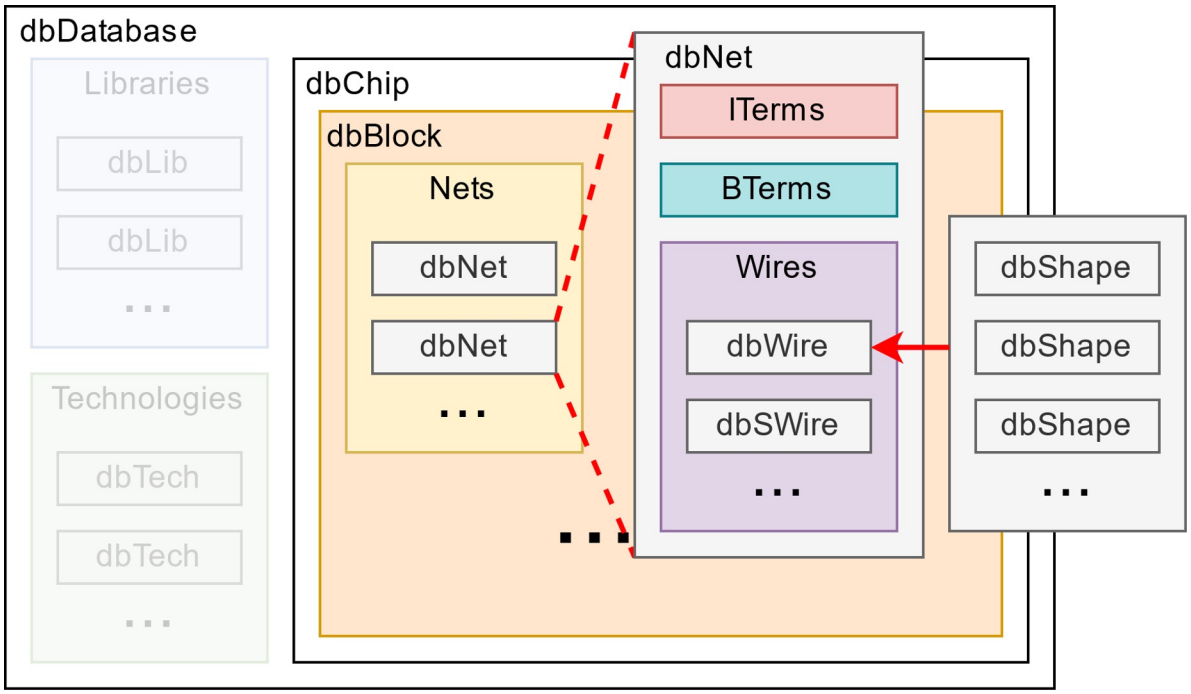
dbBlock - nets



dbNet

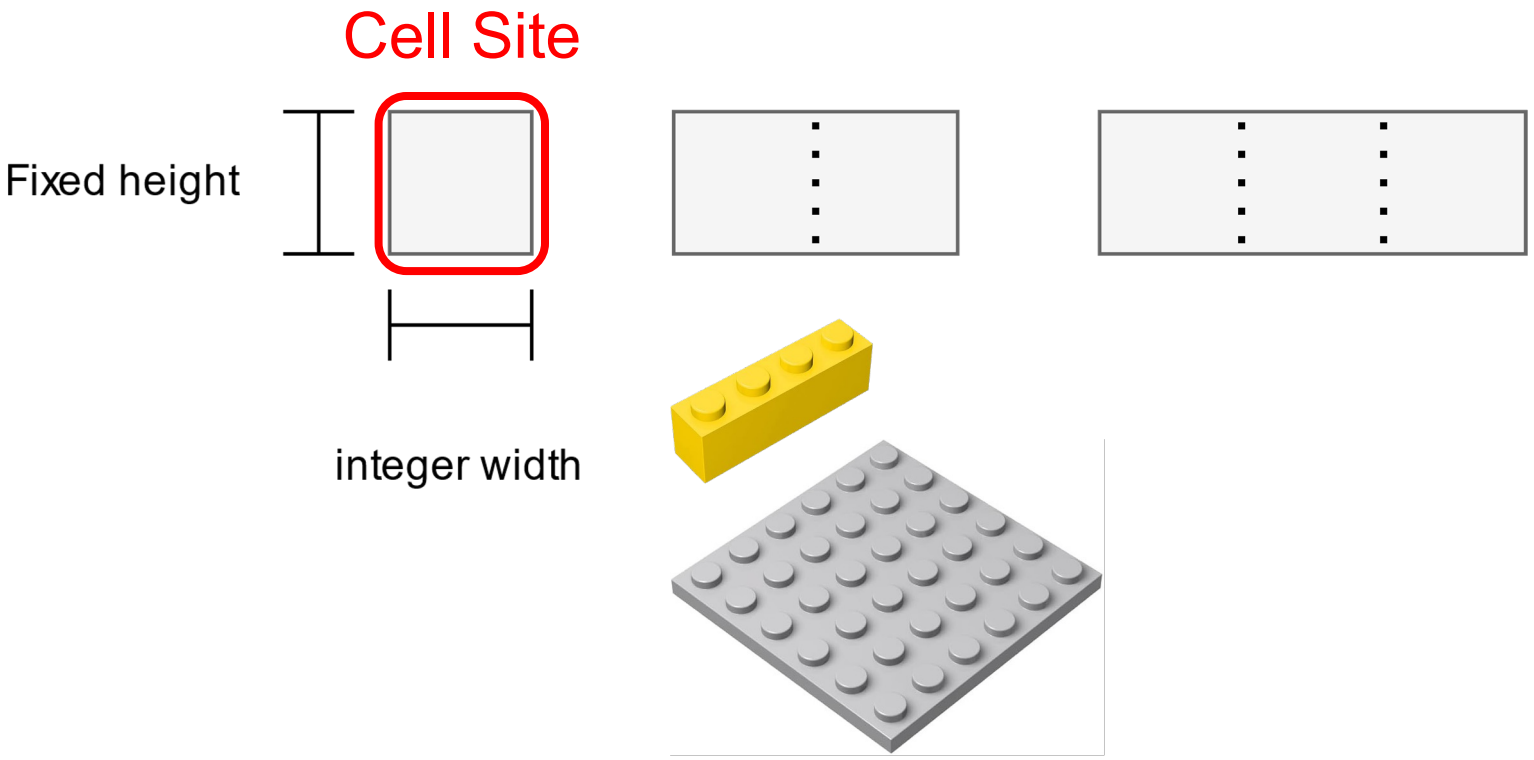

dbDatabase
Libraries
dbLib
dbLib
...
Technologies
dbTech
dbTech
...
dbChip
dbBlock
Nets
dbNet
dbNet
...
...
dbNet
ITerms
BTerms
Wires
dbWire
dbSWire
...

dbWire

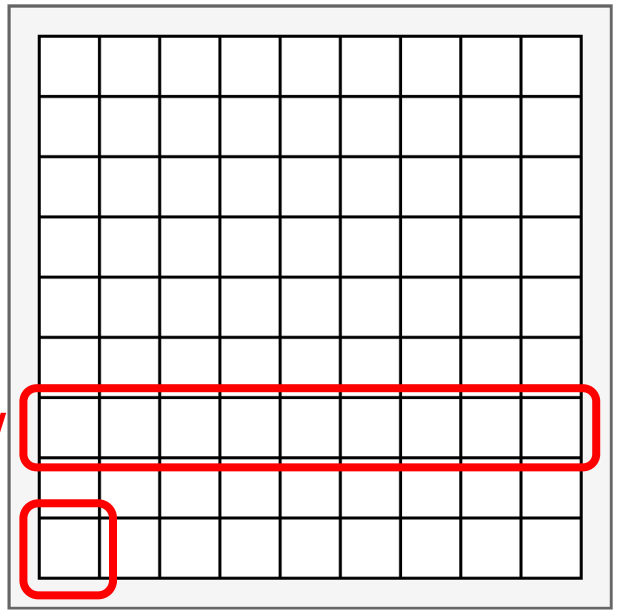

dbDatabase
Libraries
dbLib
dbLib
...
Technologies
dbTech
dbTech
...
dbChip
dbBlock
Nets
dbNet
dbNet
...
...
dbNet
ITerms
BTerms
Wires
dbWire
dbSWire
...
dbShape
dbShape
dbShape
...

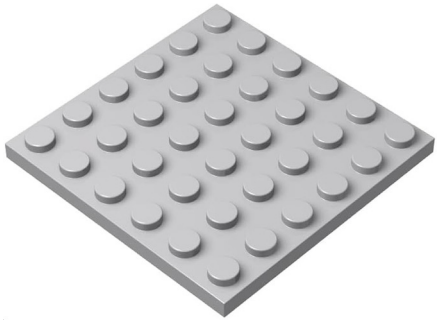
Placement

Cell Site

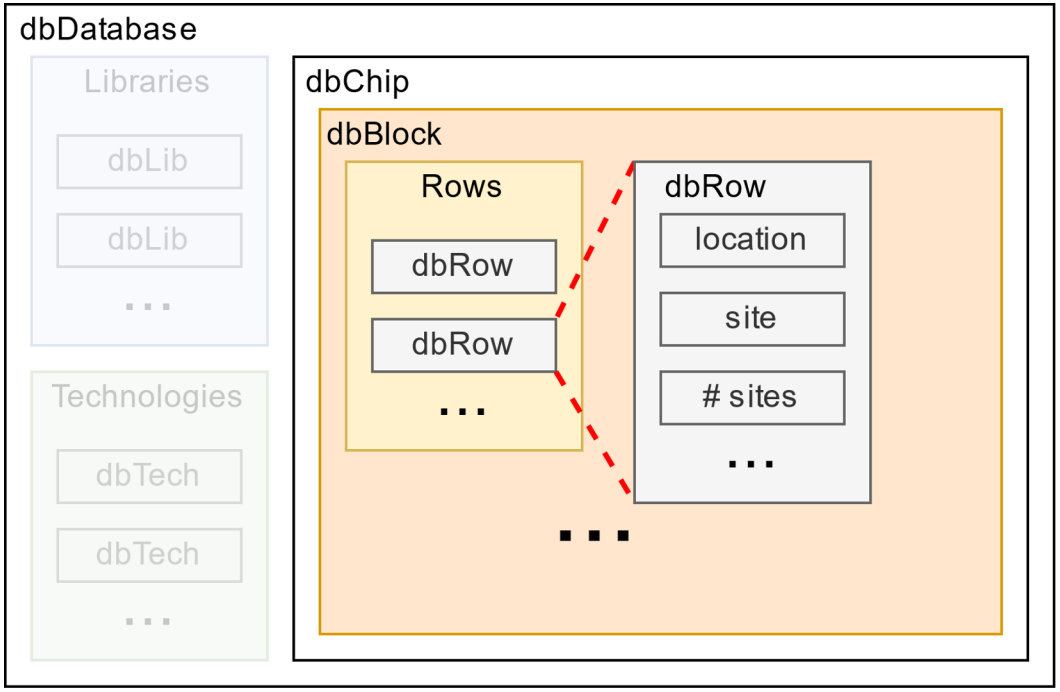


Sites and Rows





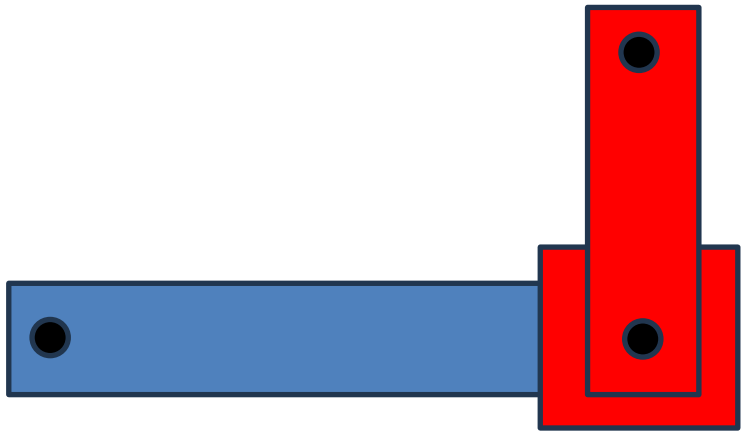
dbRow and dbSite



Wire Geometry

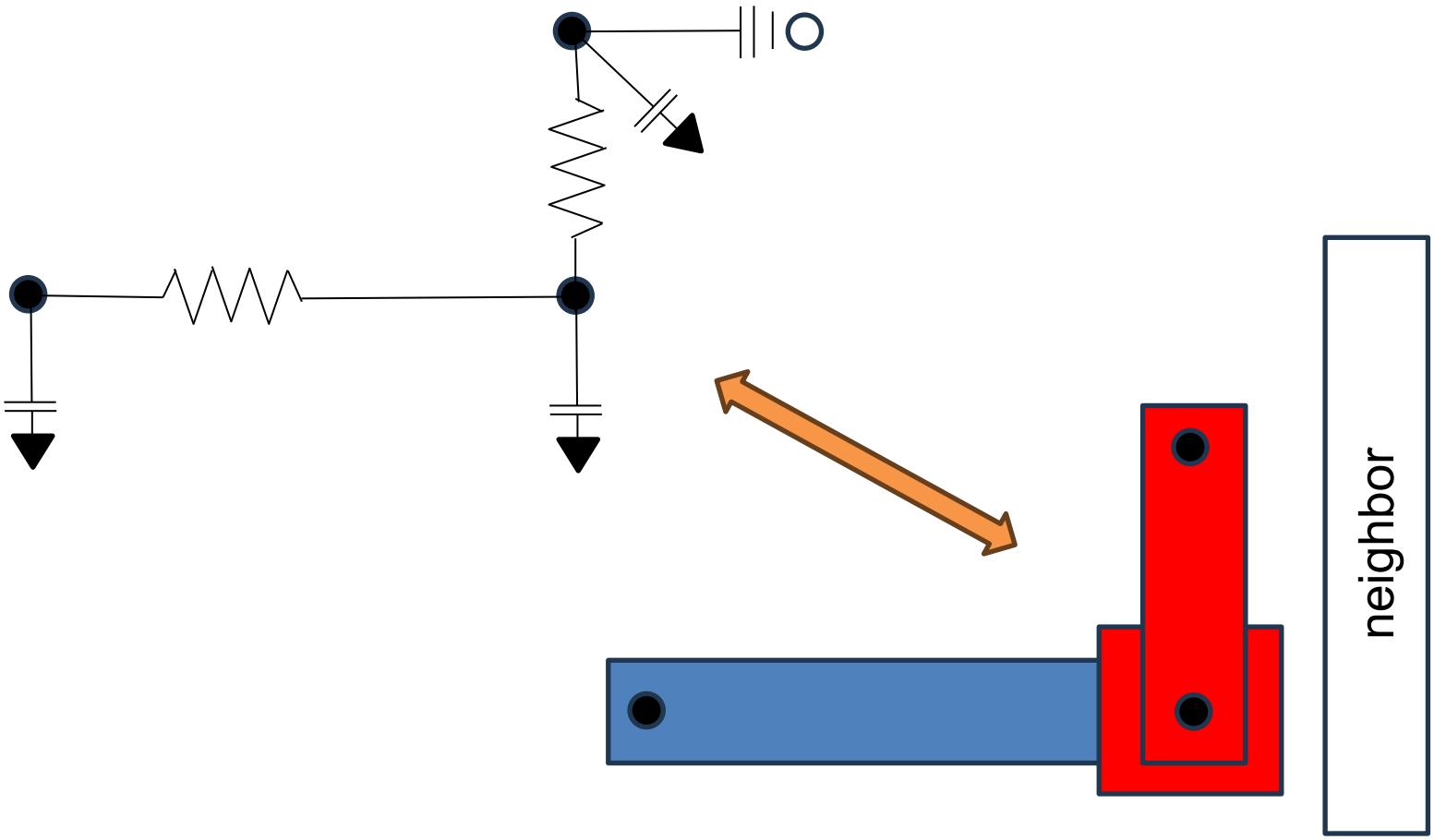
- Wires are composed:
  - Segments – a start and end point on a single layer
  - Vias – Connect wires across adjacent layers at a single point

- Wires routing can be:
  - Regular: organized into paths with connectivity
  - Special: no organization, just a pile of shapes (e.g. PDN)



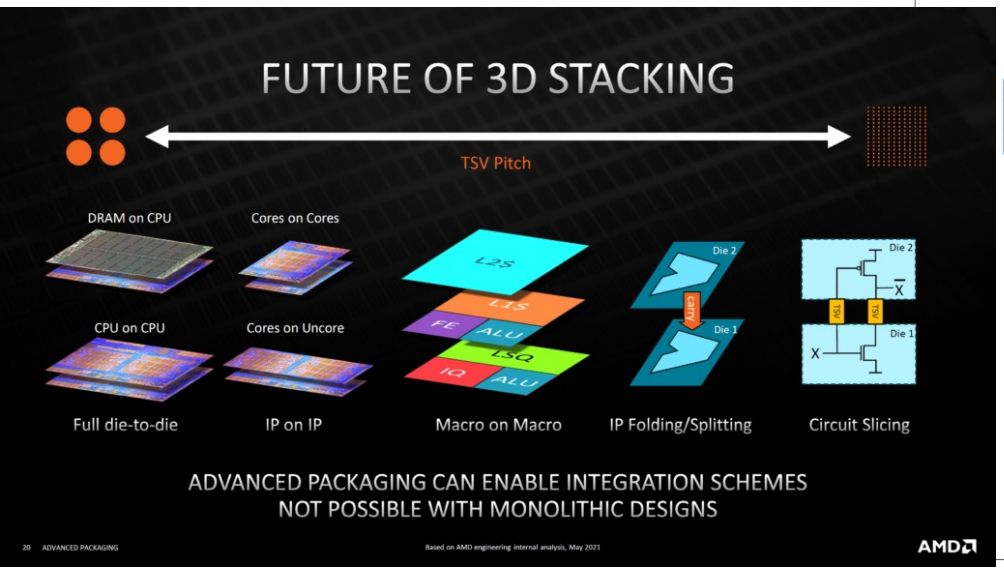
Wire Electrical Models

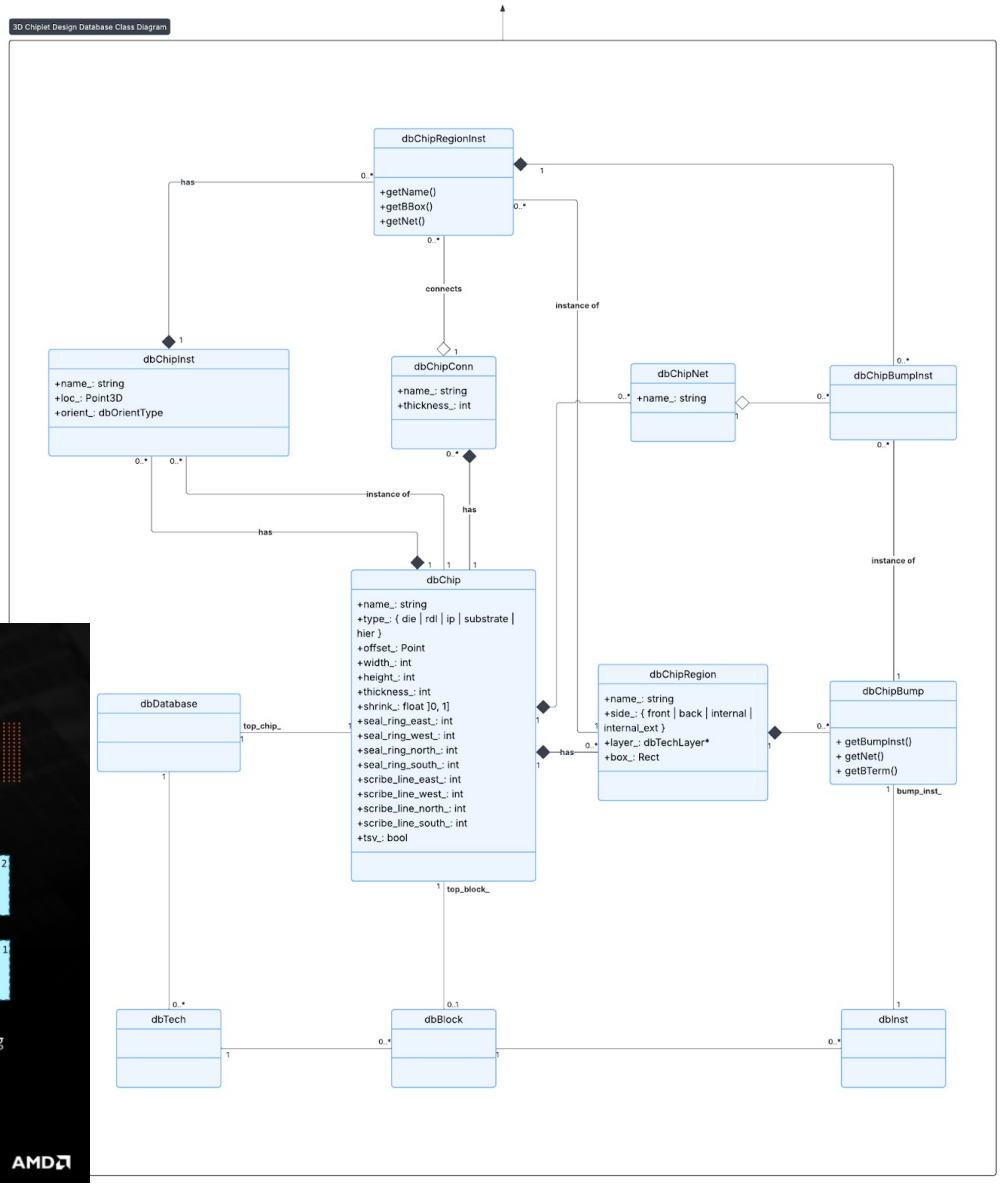
- Wire have parasitic resistance and capacitance



Chiplets

- Recently we have added support for multiple chip systems.
- A new layer of classes were added.





Thank You