IEEE P1687.1 Extending the Network Boundaries for Test

Michael Laisne - Dialog Semiconductor - A Renesas Company

Alfred Crouch – Amida Technology Solutions

Michele Portolan - Univ Grenoble Alpes, CNRS

Martin Keim – Siemens Digital Industries Software

Hans Martin von Staudt - Dialog Semiconductor - A Renesas Company

Bradford G. Van Treuren - VT Enterprises Consulting Services

Jeff Rearick - Advanced Micro Devices

Songlin Zuo – Facebook

Disclaimer

- Although I am presenting the paper submitted by the IEEE P1687 Working Group
  - I am not representing the Working Group
  - I am not speaking of on behalf of the Working Group

- All statements and comments are my own

Motivation of IEEE P1687.1

- IEEE 1687-2014, aka IJTAG, achieved great popularity
- But limited to IEEE 1149.1 Test Access Port (TAP)
  - Large number of designs feature a TAP
  - But not all

- Other type of interfaces, e.g. I2C, SPI, in-house, …
- Still want to use IJTAG internal to the device

Motivation of IEEE P1687.1

Brief history

- Study Group formed ITC'15, Working Group approved in 2016

Title

- Standard for the Application of Interfaces and Controllers to Access 1687 IJTAG Networks Embedded Within Semiconductor Devices

Objectives

- Extends or expands application of 1687
- Allow use/description of range of IC interfaces and their controllers
- Use I^2C, SPI, …, "any" future (synchronous) slow interface

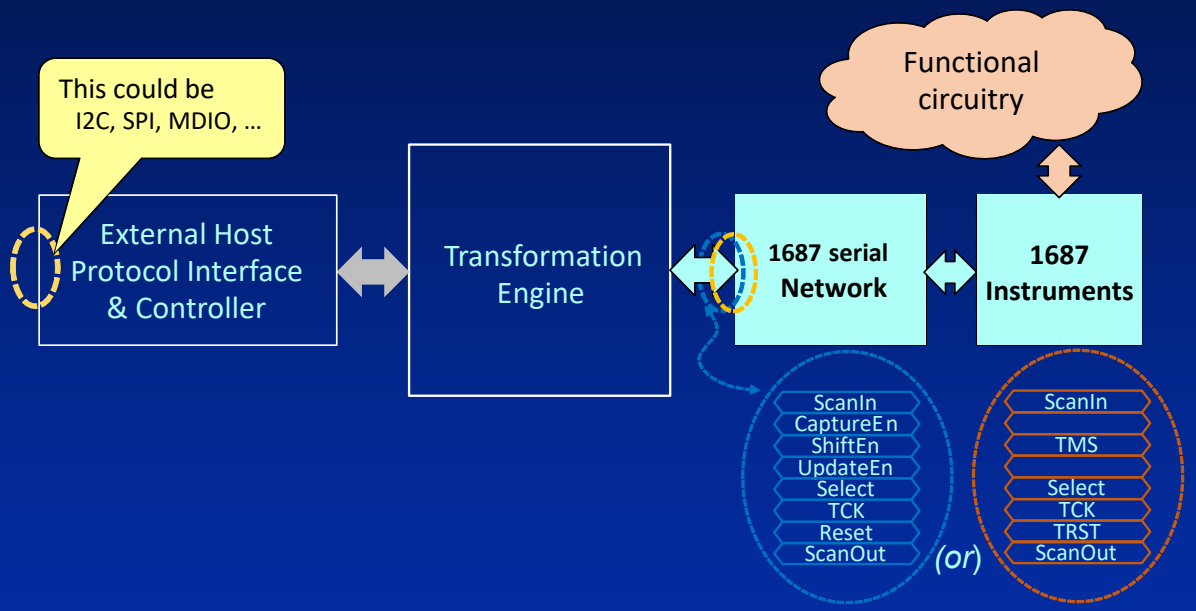
Outline

- Principles
- Recap IEEE P1687.1
- Solutions outline
- Summary

Principles

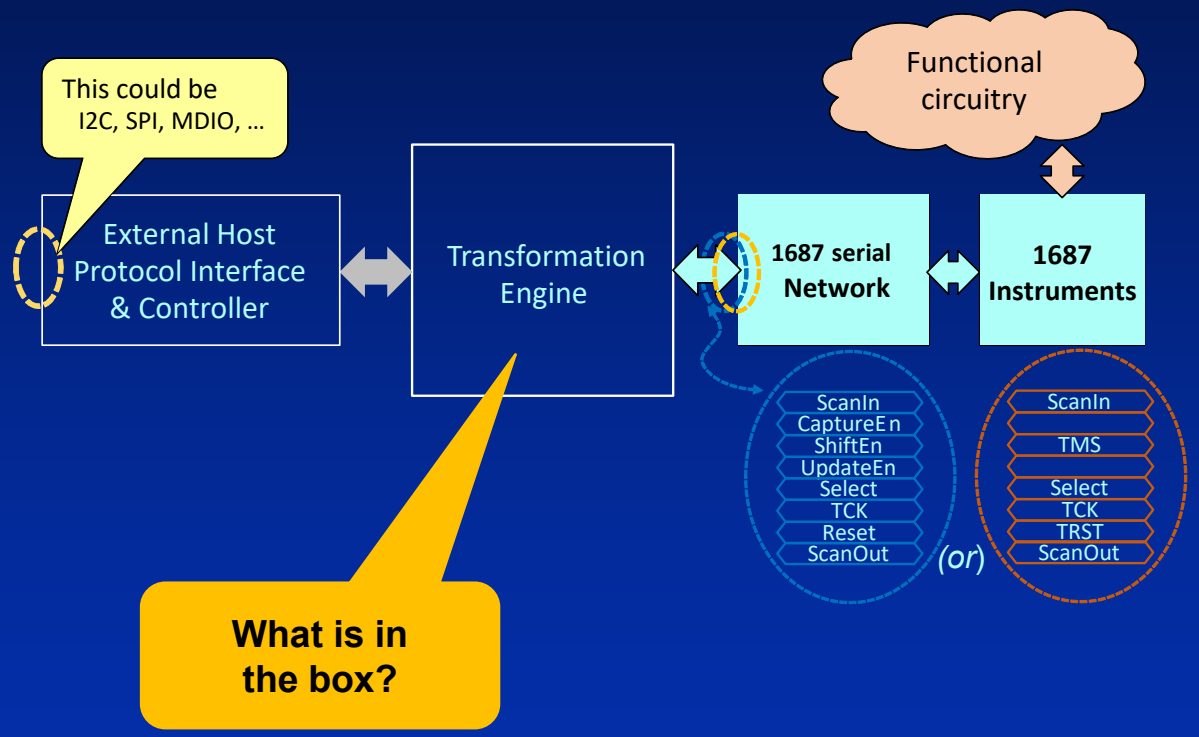
- Don’t change IEEE 1687 unless *really, really* necessary
  - Coordinate with IEEE P1687 Refresh Working Group
- Enable the work of IEEE P2654
  - Create a P1687.1 solution what will integrate in P2654
- Remain a descriptive standard
  - Do not prescribe the what & how to implementers or users
  - Describe interfaces and access points ← This presentation!

Recap P1687.1



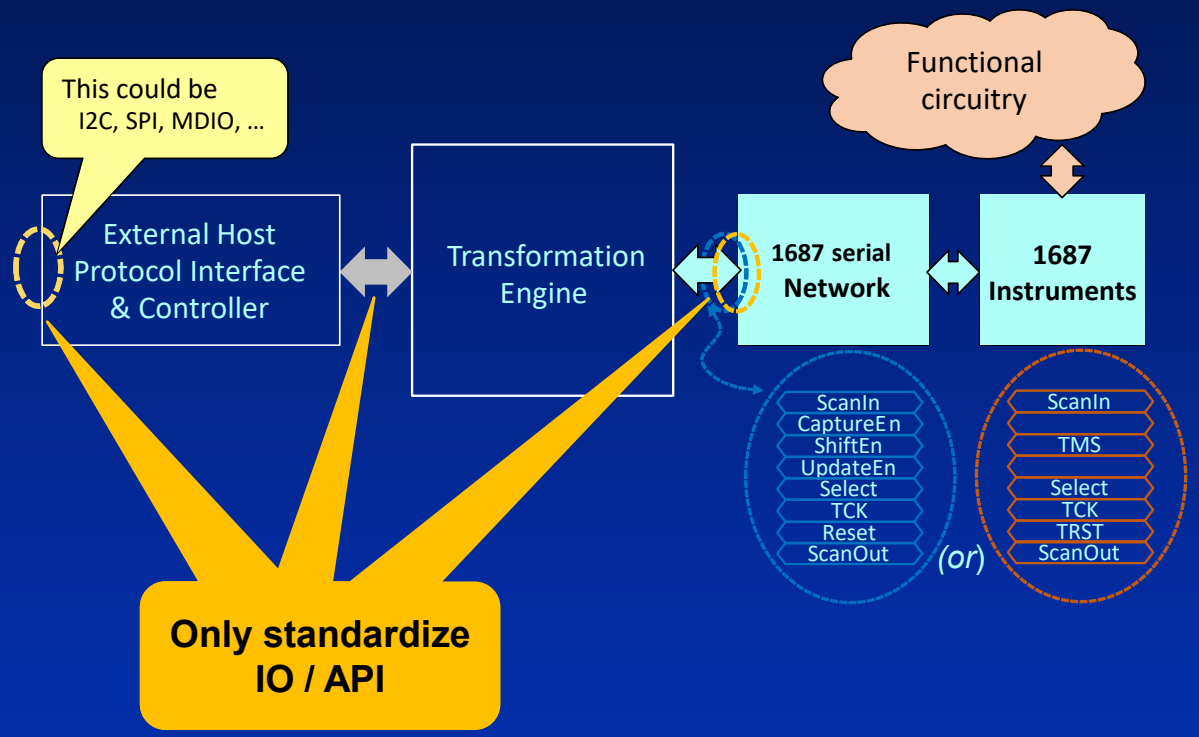
- Access & operation of an IEEE 1687 network through a non-Tap interface
- How to describe the "Transformation Engine"?
- How to interface to *tools*?

Towards the Solution



- P1687.1 must not care!
  - Will not prescribe IP
  - Will not prescribe function
- This is property and responsibility of the owner of the transformation engine

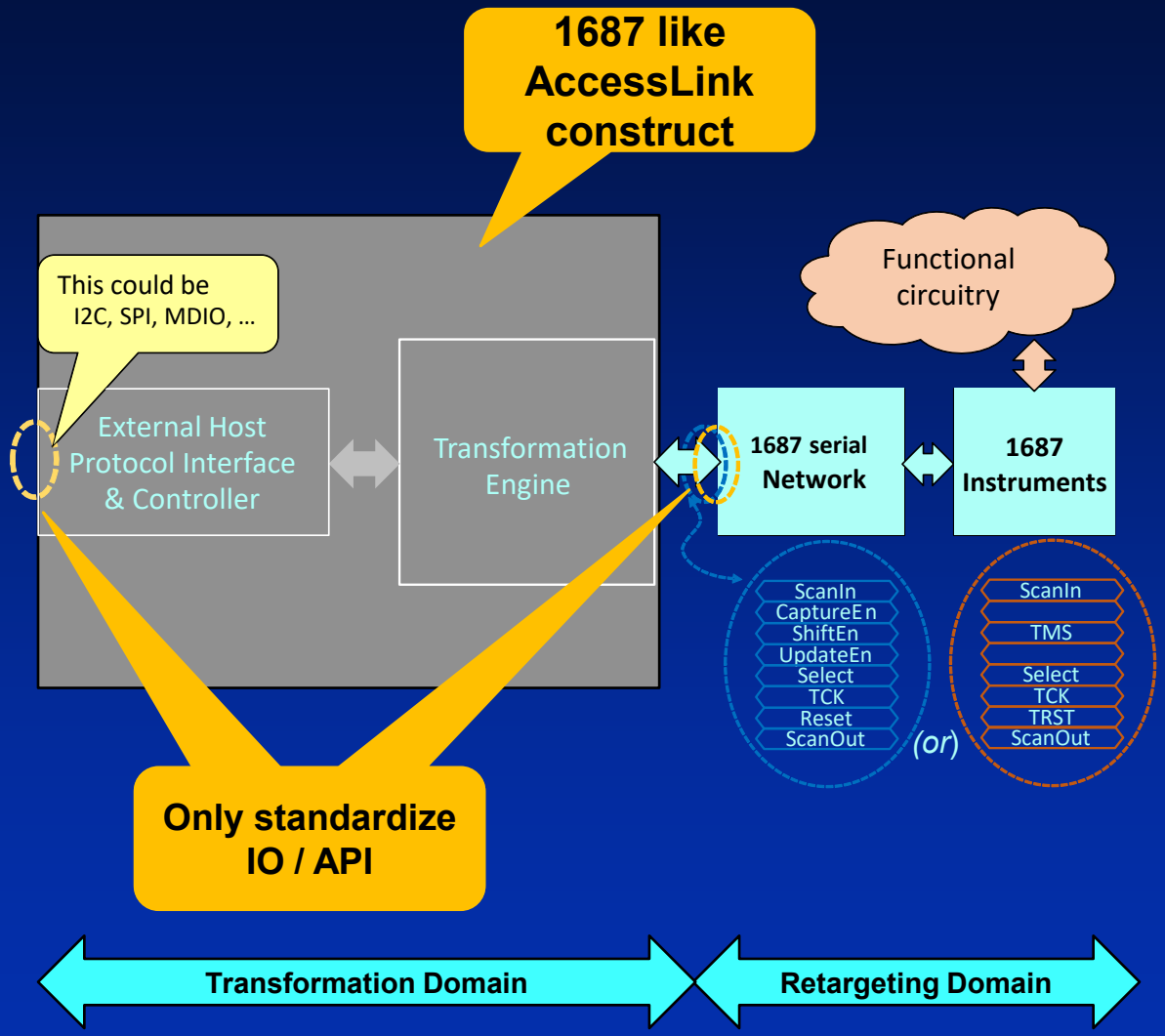
Towards the Solution



- P1687.1 only describes the interfaces to / from the Transformation Engine box

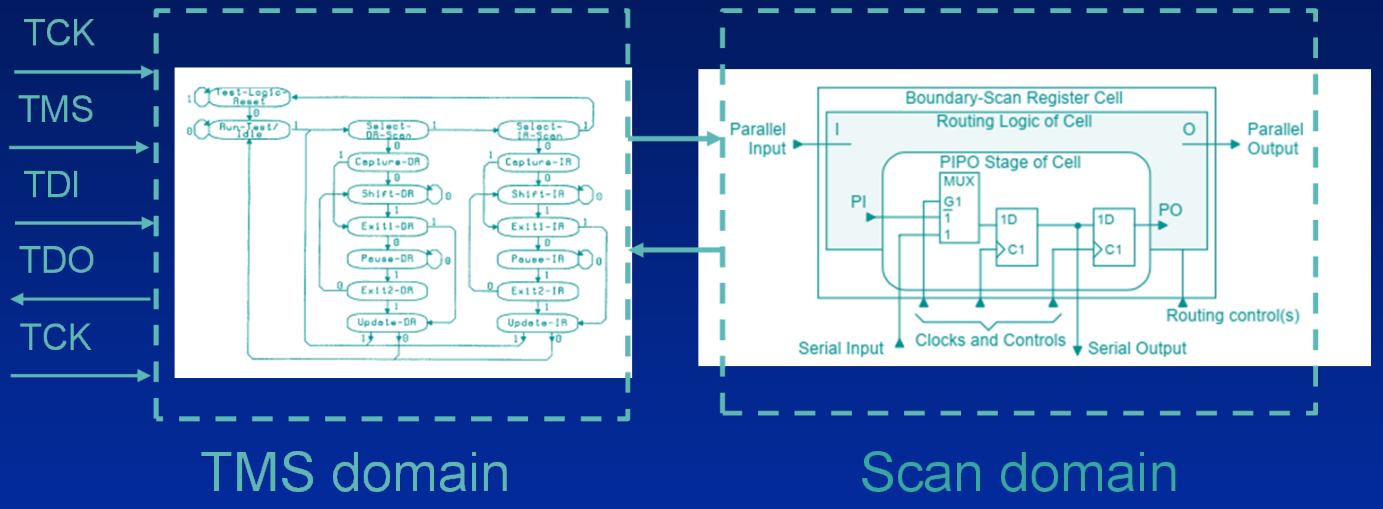
- Follow-up question: How?
- Some detailed questions
  - How to interface to 1687 EDA tool?
  - Who writes the patterns on the left?

Towards the Solution



- 1687 AccessLink like construct
- Hook of ICL description to design
- Container or place of reference for Transformation Engine "code"
  - ICL/PDL cannot describe behavior
  - Code = User piece of software that transforms the retargeted PDL data to the EHPIC
- Requires domain specific language

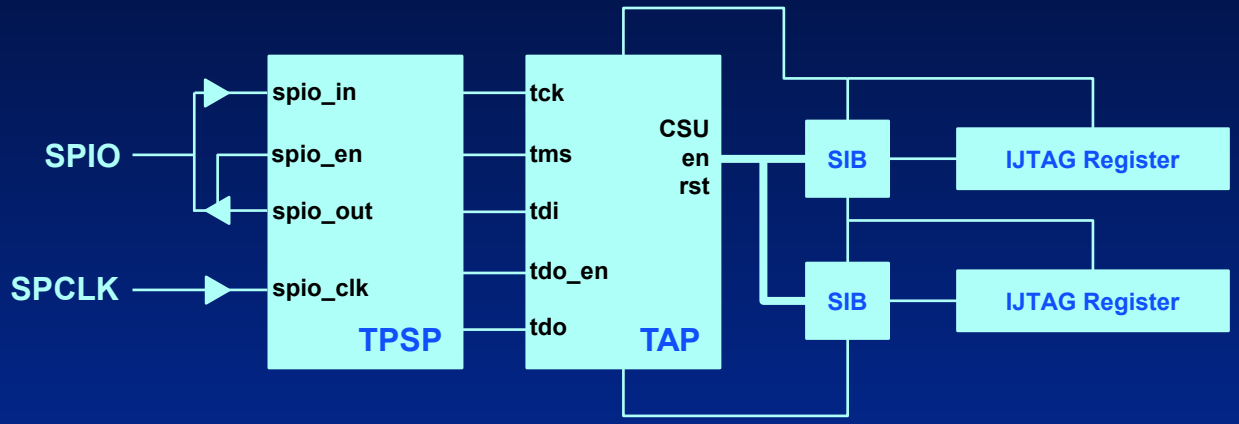
Domain specific languages are nothing new



- TMS Domain
  - Defines the method to navigate the FSM
  - Only certain sequences of TMS values are meaningful
- Scan Domain
  - Composed by connecting specific elements like the Boundary Scan Cells
- Standard document & specific protocol
  - Serial Vector Format (SVF)
  - Boundary Scan Description Language (BSDL)

Example System

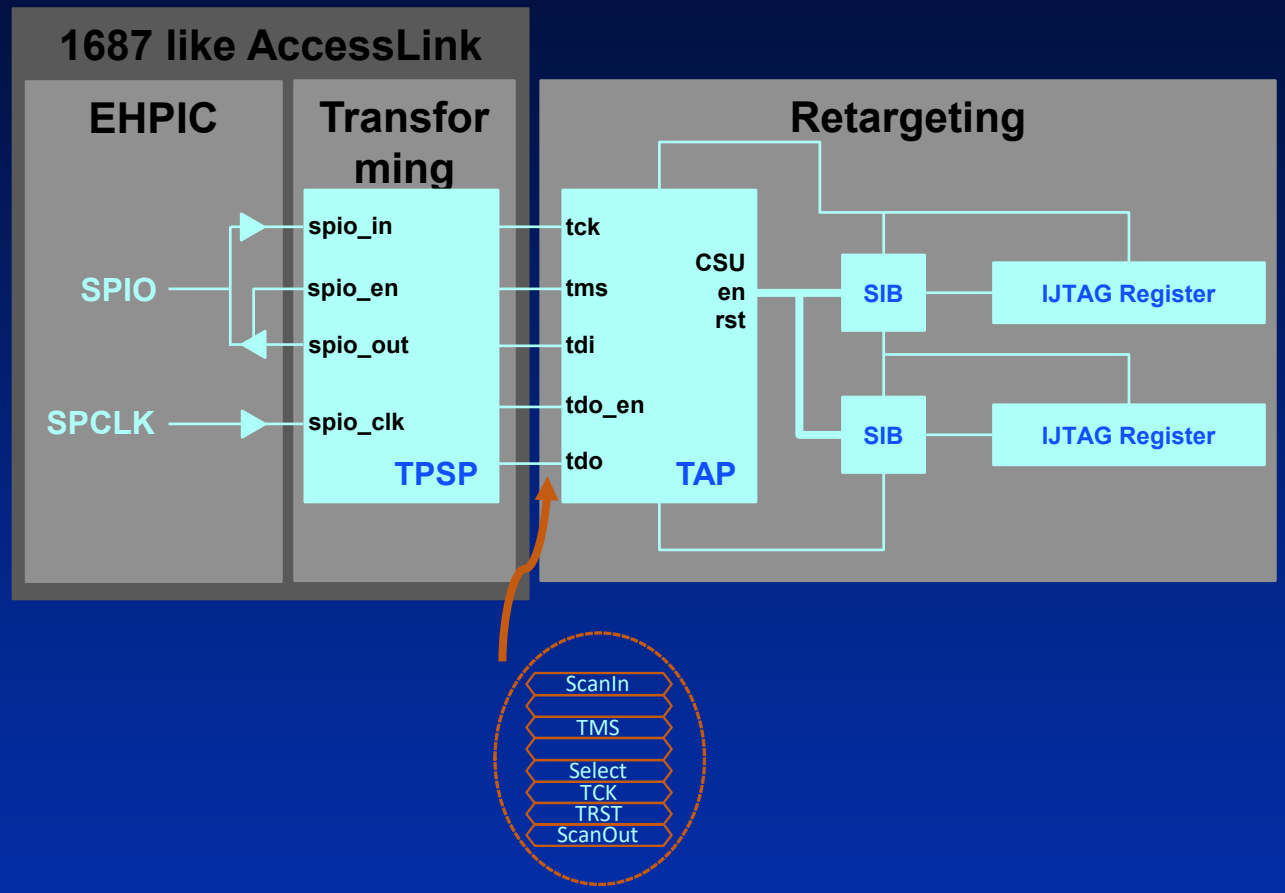
- Two-Pin Serial Port (TPSP) interface



- TPSP controls the TAP
- Bit-banging the interface based on three cycles
  - controlled by SPCLK
  - two cycles are used to push TDI and TMS data to the TAP
  - the third one is used to retrieve TDO from it

Example System

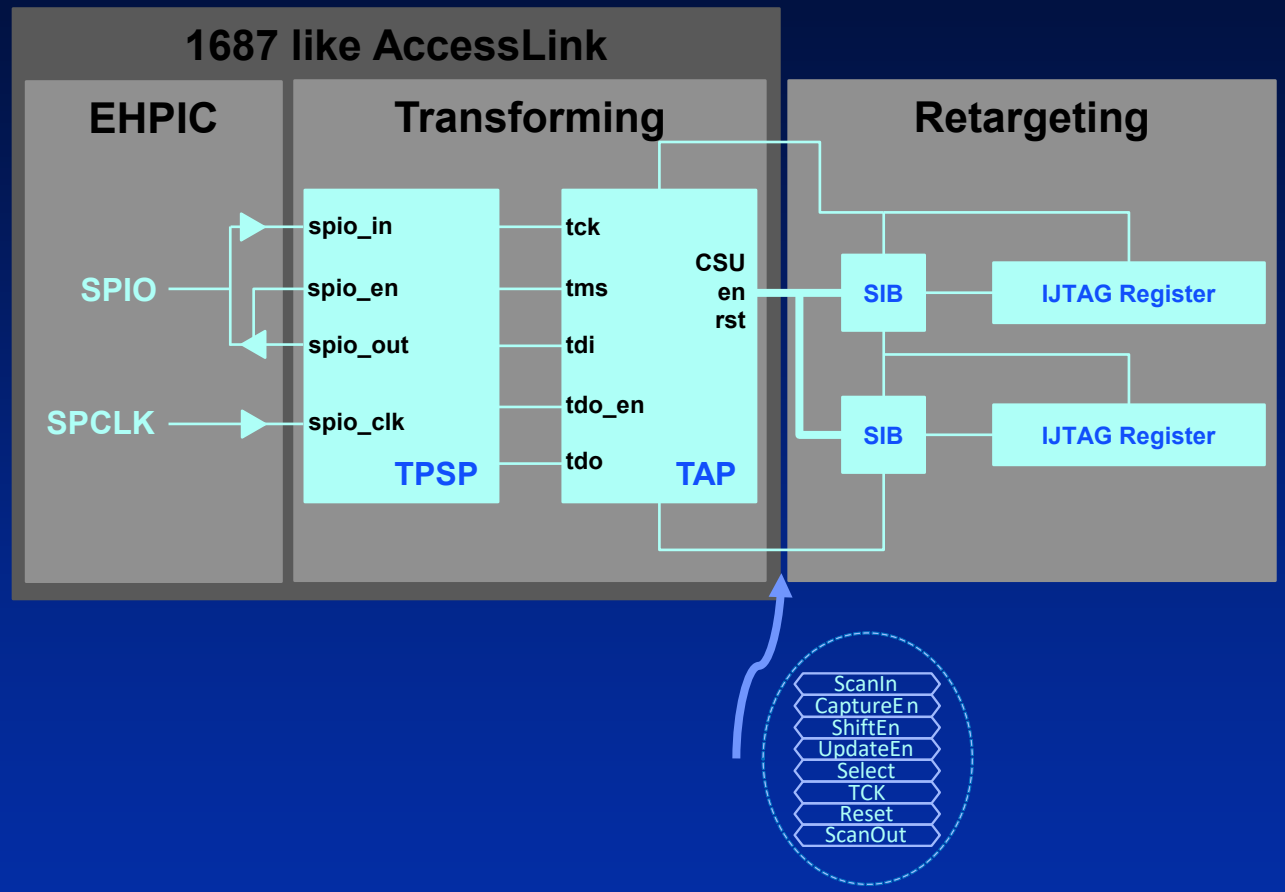
- Transformation does not include TAP
- API to encode
  - Scan-in / out
  - TMS
  - Select
  - TCK
  - TRST



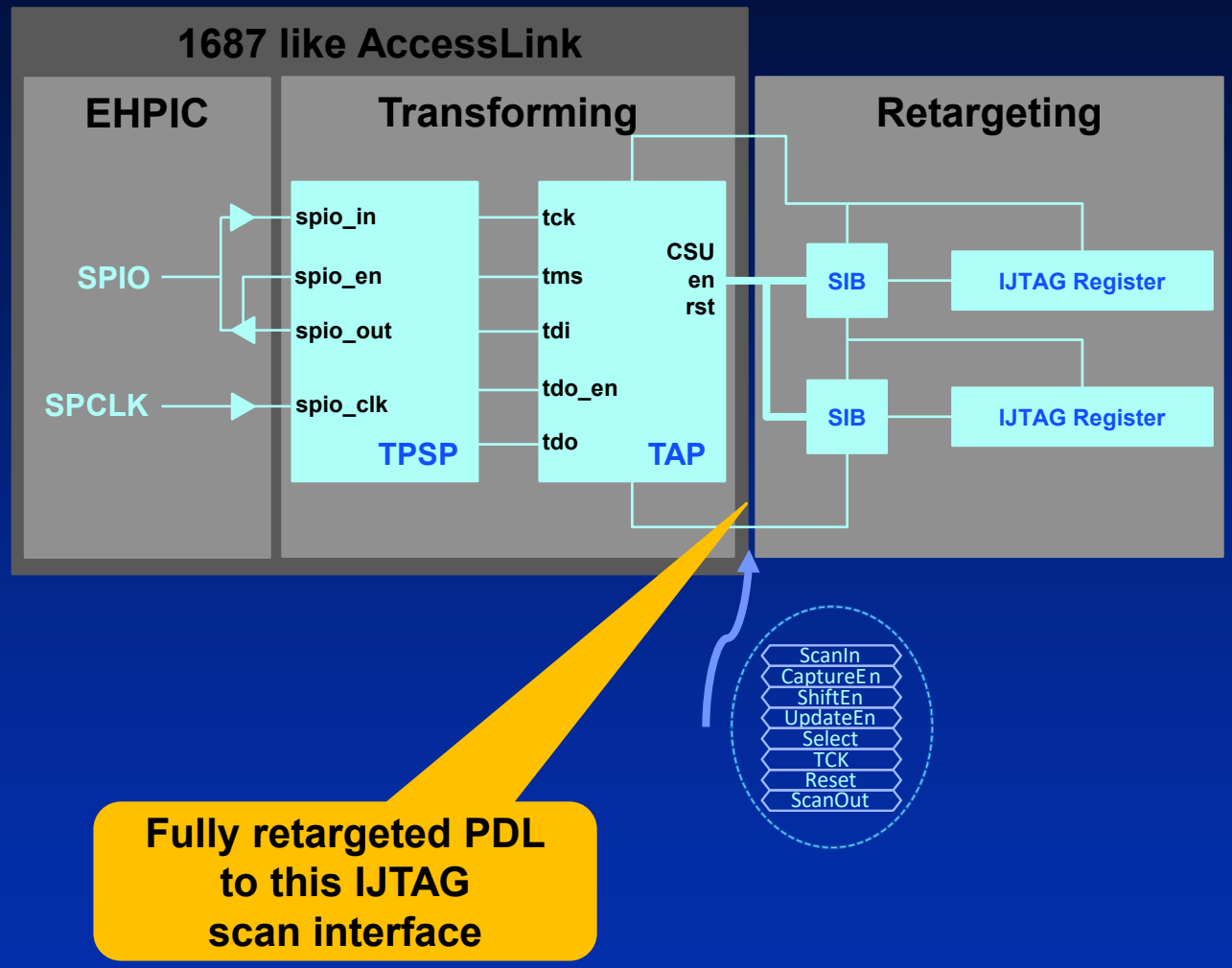
Example System

- Transformation includes TAP

- API to encode
  - Scan-in / out
  - Capture / Shift / Update Enable
  - Select
  - TCK
  - Reset

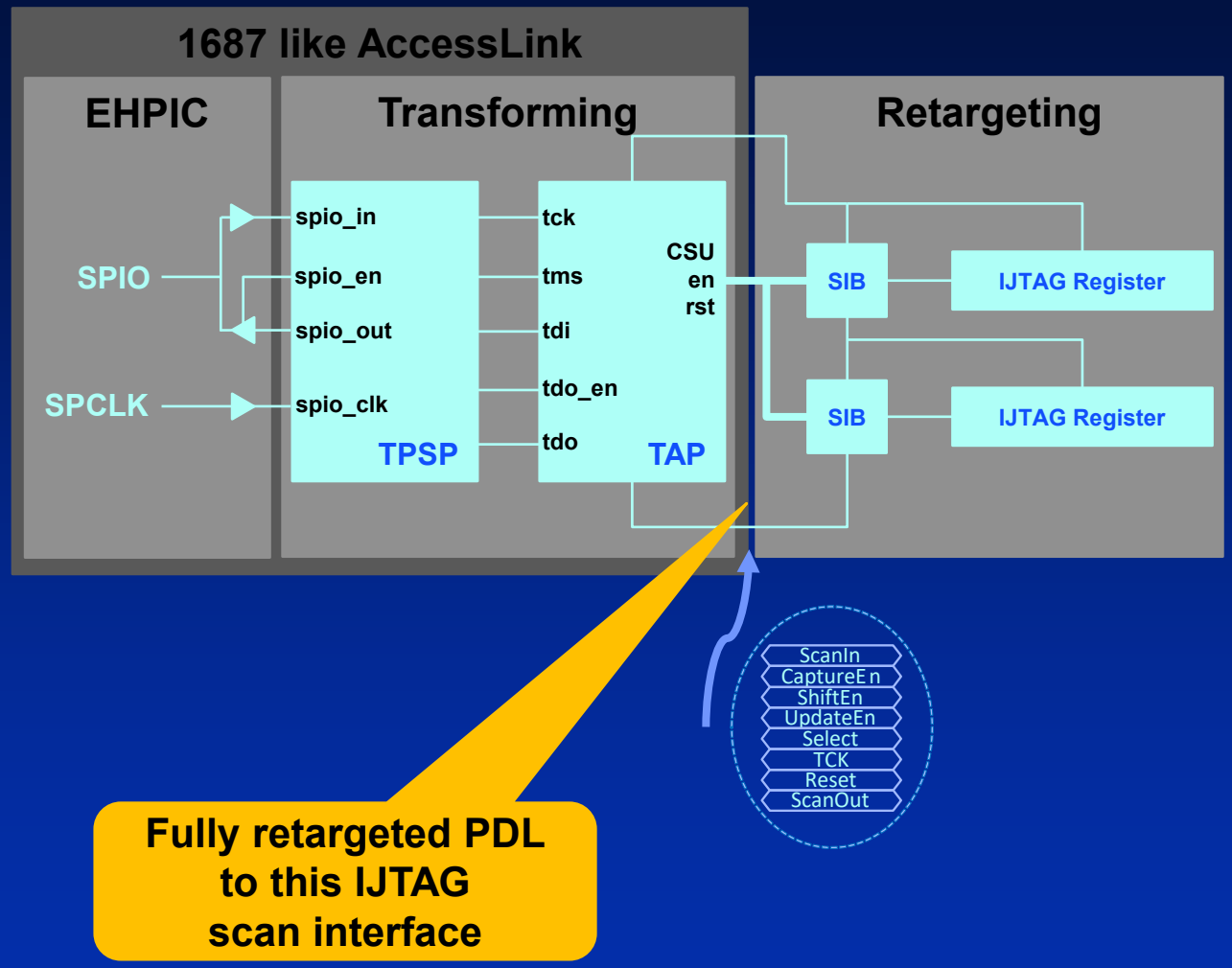


Example System



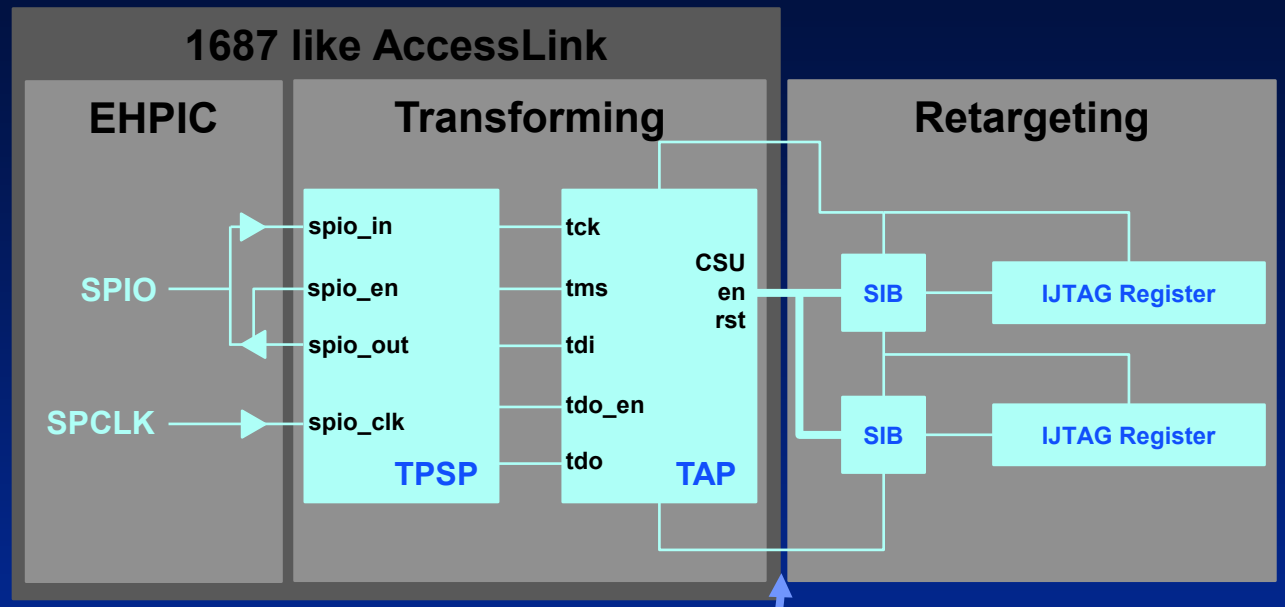
Example System

- An API can present the data to the TPSP transformation
- This API can be standardized
- It is a small list
  - CSU, PI, PO, PIO
  - Wait, Note, Idle,
  - …



Example System

- This API can be standardized
- P1687.1 is looking into Google's Protocol Buffers (protobuf) as a universal solution
- Message
  - E.g. CSU event
  - Data




```
Message CSU_Request {
      bool is_ir = 1;
      string interface_name = 2;
      int32 chain_id = 3;
      Int32 length = 4;
      PDLNumber si = 5;
      PDLNumber so = 6;
      bool is_stable = 7;
}
```

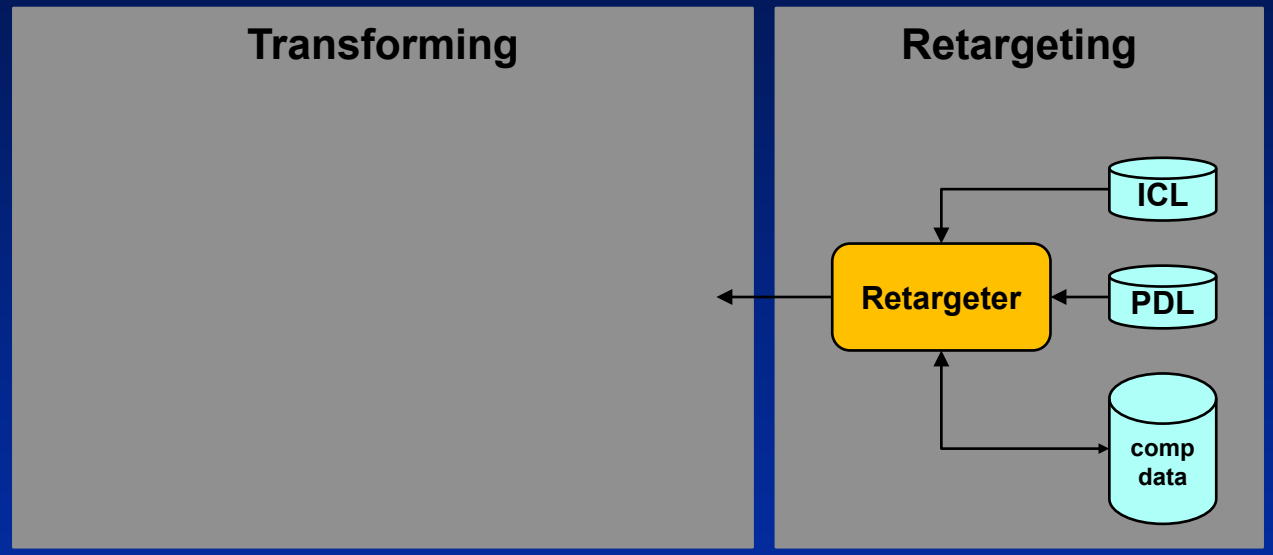
```
Message IRunLoop_Request {
      int32 cycle_count = 1;
      bool tck = 2;
}

Message iReset_Request {
      bool sync = 1;
}
```

What are protobufs?

- Protobuf = Protocol Buffers
- Google: https://developers.google.com/protocol-buffers
- A language-neutral, platform-neutral, extensible mechanism for serializing structured data (think of XML kind of idea)
- Protocol buffers currently support generated code in Java, Python, Objective-C, and C++

P1687.1 Standardization Opportunities

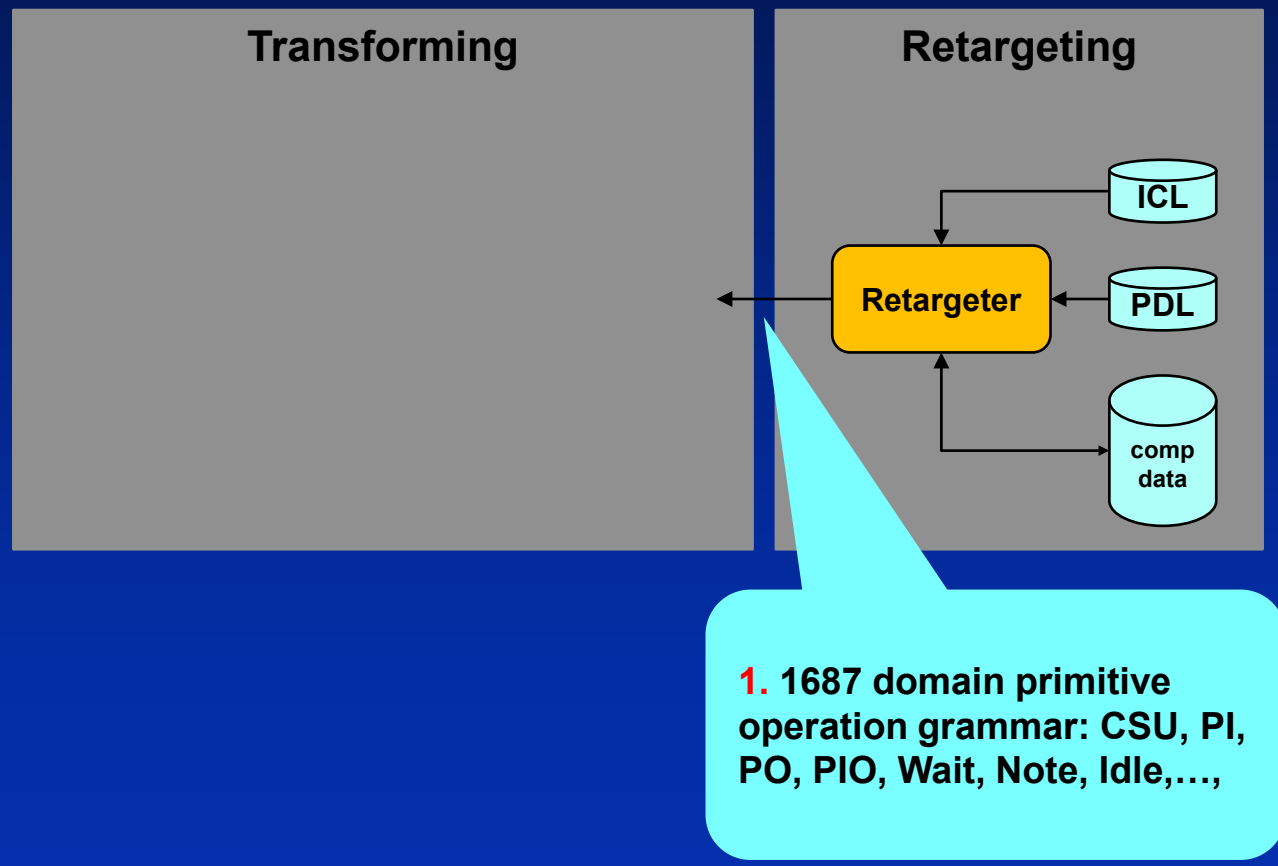


EDA tool support

EDA provided

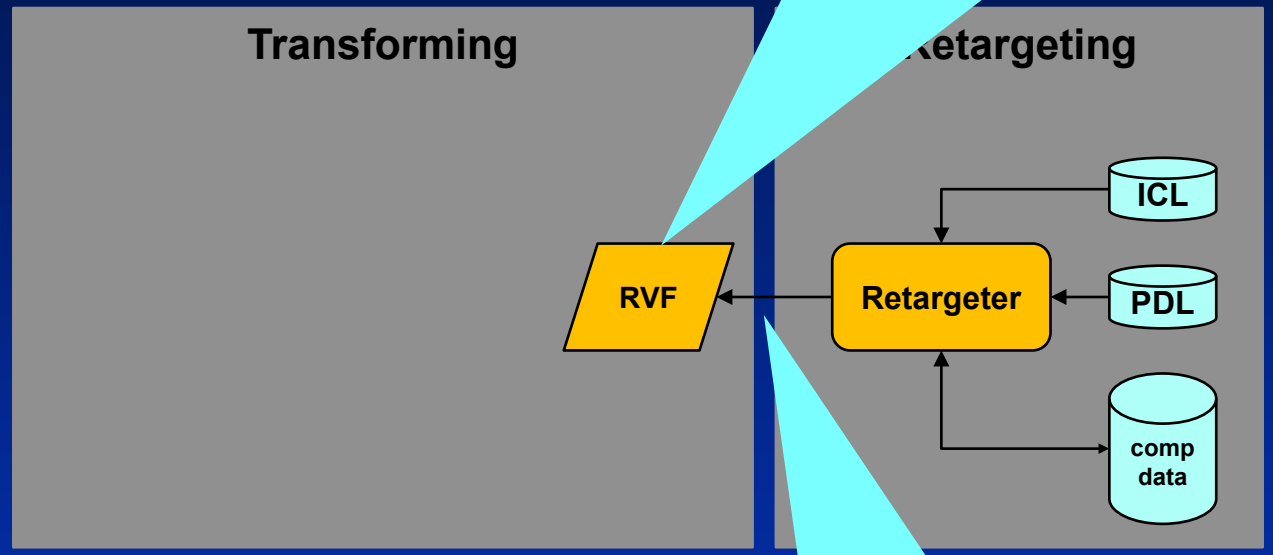
User provided

P1687.1 Standardization Opportunities



P1687.1 Standardization Opportunities

2. RVF
Messages: Request, Response
Delegation: to TransferProcs
Error handling: bad message, bad operation (metadata);



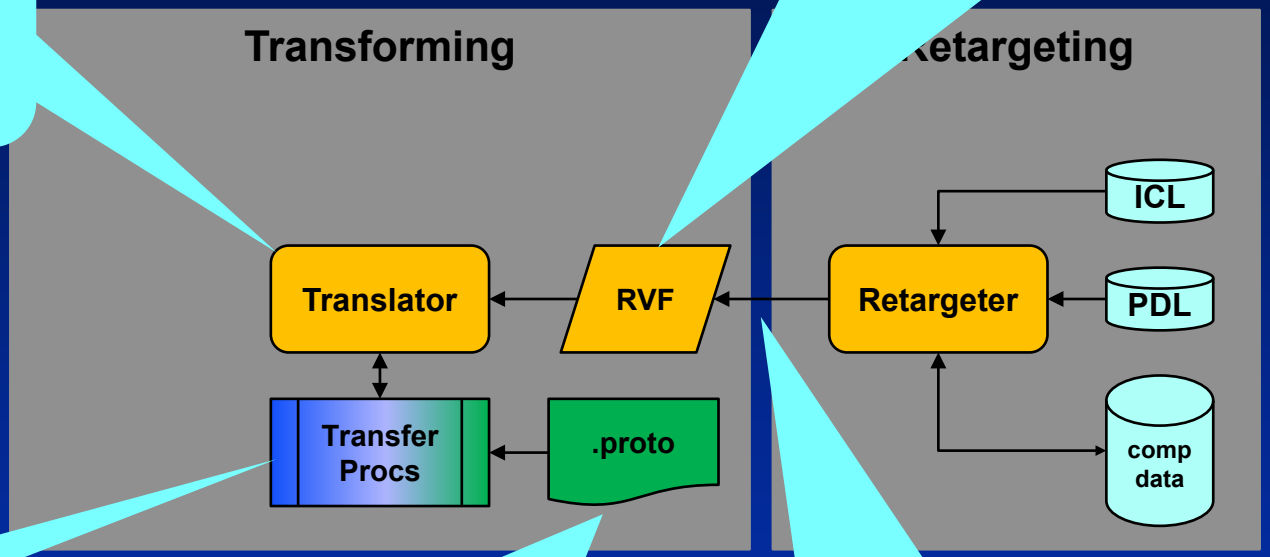
EDA tool support
EDA provided
User provided

1. 1687 domain primitive operation grammar: CSU, PI, PO, PIO, Wait, Note, Idle,…,

P1687.1 Standardization Opportunities

2. RVF
Messages: Request, Response
Delegation: to TransferProcs
Error handling: bad message, bad operation (metadata);

4. Translator actions:
- Recognize message types
- Delegate handling of RVF
- Handle errors



EDA tool support
EDA provided
User provided

5. Transfer Proc structure:
- Written in terms of the primitive operation grammars

3. Protobuf:
{ID}{Op (CSU, PI, PO, PIO, Wait, Note, Idle,…)}
{payload of serialized data}

1. 1687 domain primitive operation grammar: CSU, PI, PO, PIO, Wait, Note, Idle,…,

Relocatable Vector Format (RVF)

RVF Request		
Field Name	Type	Description
Data/Mask	Binary	Binary representation of the vector to be sent to the SUT
Callback_idf	String	Unique Callback identifier
Optional Data	binary	Callback-specific data
RVF Result		
Field Name	Type	Description
Data	Binary	Binary representation of the vector received from the SUT
Status	Binary/String?	Status information about last Request

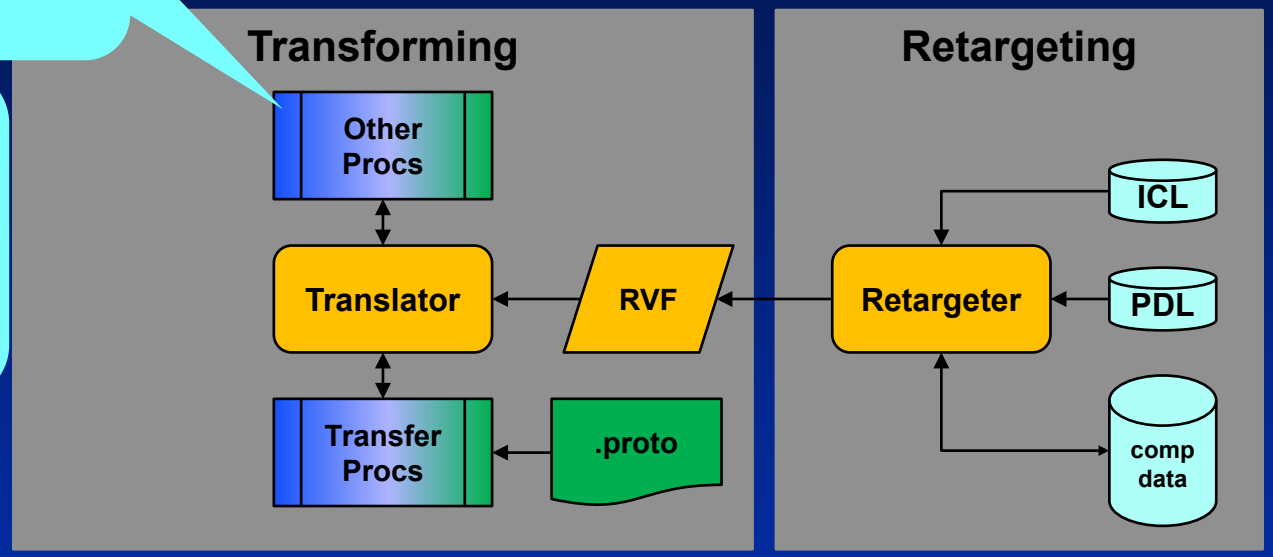
- Abstract Information exchanged between translators
- Can be implemented as needed
  - Protobuf for EDA exchange
  - Binary data structure for internal processing
  - …etc…
- Exact content yet TBD

P1687.1 Standardization Opportunities

Provides e.g.
- **Debug data / dump / log**
- **Write user pattern format**

iWrite RegA 0x55AA

```
i2c_write(0x7F);   # TE addr
i2c_write(0x10);   # write cmd
i2c_write(0x02);   # num bytes
i2c_write(0x55);   # first byte
i2c_write(0xAA);   # next byte
```



EDA tool support

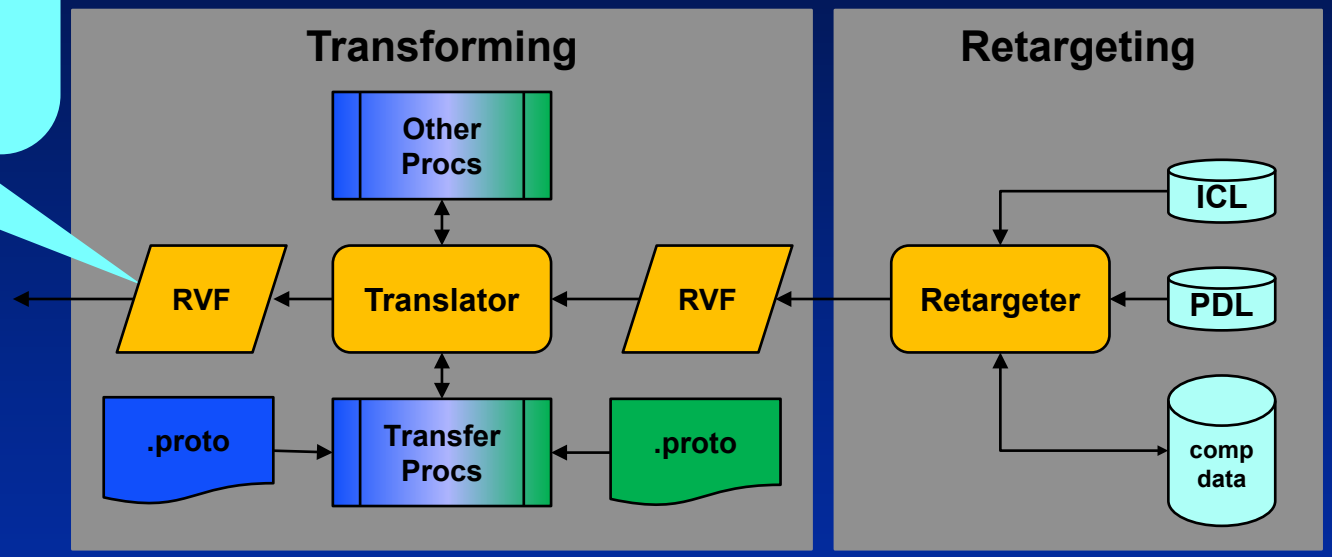
EDA provided

User provided

P1687.1 Standardization Opportunities

1. For P2654 alignment

2. Alternative path for pattern
- Use second Transforming box, just for the pattern syntax
- Return data to EDA tool

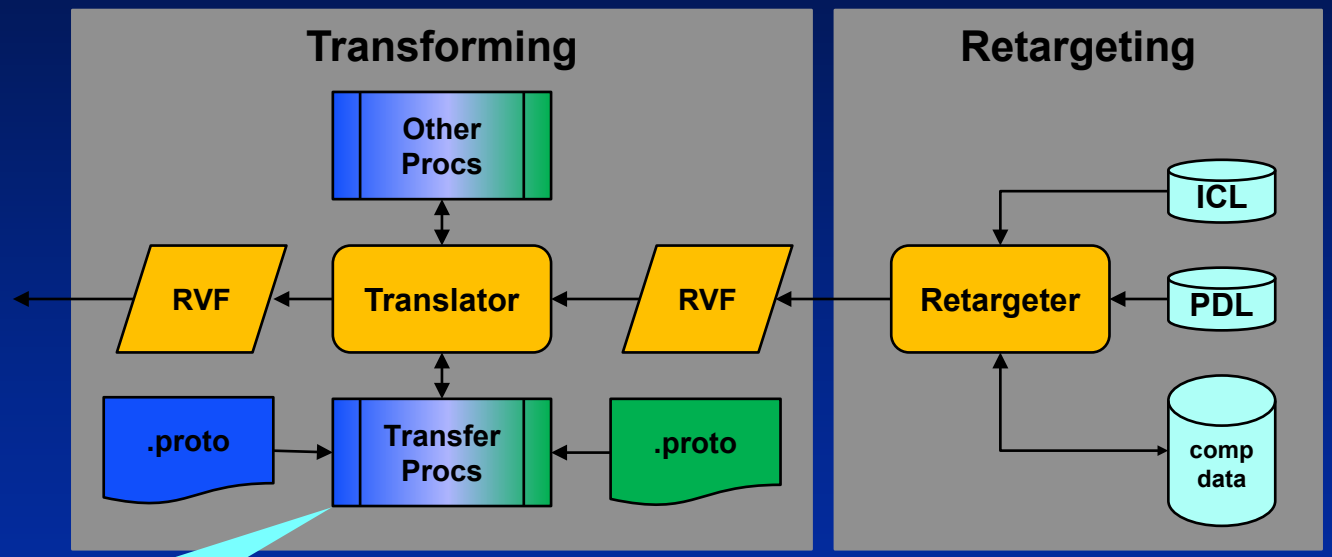


EDA tool support

EDA provided

User provided

P1687.1 Standardization Opportunities



Pattern debug and diagnosis

Transfer Procs must maintain tracking information:
Where every bit comes from /goes to

Summary

- IEEE P1687.1 WG has made great progress identifying what needs to be standardized and how this can be achieved

- Current focus:
  - Run these ideas through detailed examples with focus on what to standardize, what not, and how
  - These examples are planned to be added to the draft

Any Questions?

- Want to join the IEEE P1687.1 Working Group?
- Contact the Secretary at Martin_Keim@Mentor.com