Lets be Formal While Talking About Verification Quality: A Novel Approach Of Qualifying Assertion Based IPs

Surinder Sood, Sachin Scaria, Erik Seligman

AGENDA

- Introduction: VIP & The 3 Cs
- Checking Consistency : Self-FPV
- Checking Completeness : Fault Injection + FPV
- Conclusions and Future Work

AGENDA

- Introduction: VIP & The 3 Cs
- Checking Consistency : Self-FPV
- Checking Completeness : Fault Injection + FPV
- Conclusions and Future Work

Introduction: VIP & The 3 Cs

- Verification IP (VIP) is increasingly critical
  - Ideally supports both formal & simulation
  - Our emphasis in on formal
- Major requirements for VIP:
  - Correctness: VIP == spec?
    - » Beyond the scope of this talk
  - Consistency: VIP fits together & allows good behaviors?
  - Completeness: VIP flags all bad behaviors?
- Consistency & Completeness: Use Formal Property Verification (FPV)

Assertion-Based VIP Structure

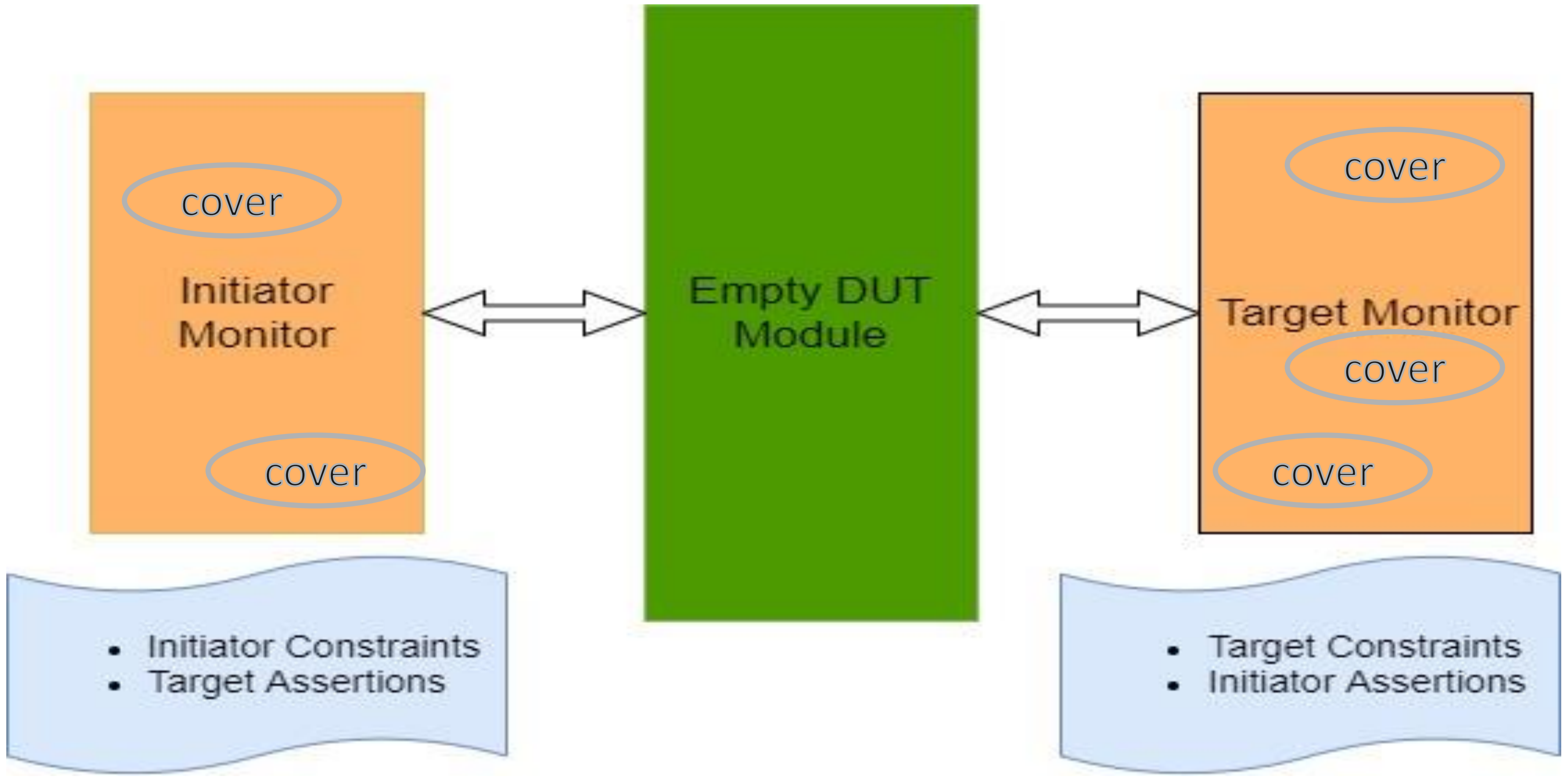
- **Assumptions/Constraints** : limit allowable input activity
- **Assertions** : conditions that must be true
  - Failing assertion flags error (in simulation or formal)
- **Covers** : conditions that must be tested
  - Missed cover in simulation == need more testing
  - Missed cover in formal == overconstrained

… + modeling code (queues, scoreboards, …)

AGENDA

- Introduction: VIP & The 3 Cs
- Checking Consistency : Self-FPV
- Checking Completeness : Fault Injection + FPV
- Conclusions and Future Work

Checking Consistency: Self-FPV



Assumptions/Constraints must allow known legal behaviors
Covers == core concepts, spec waveforms, known corner cases

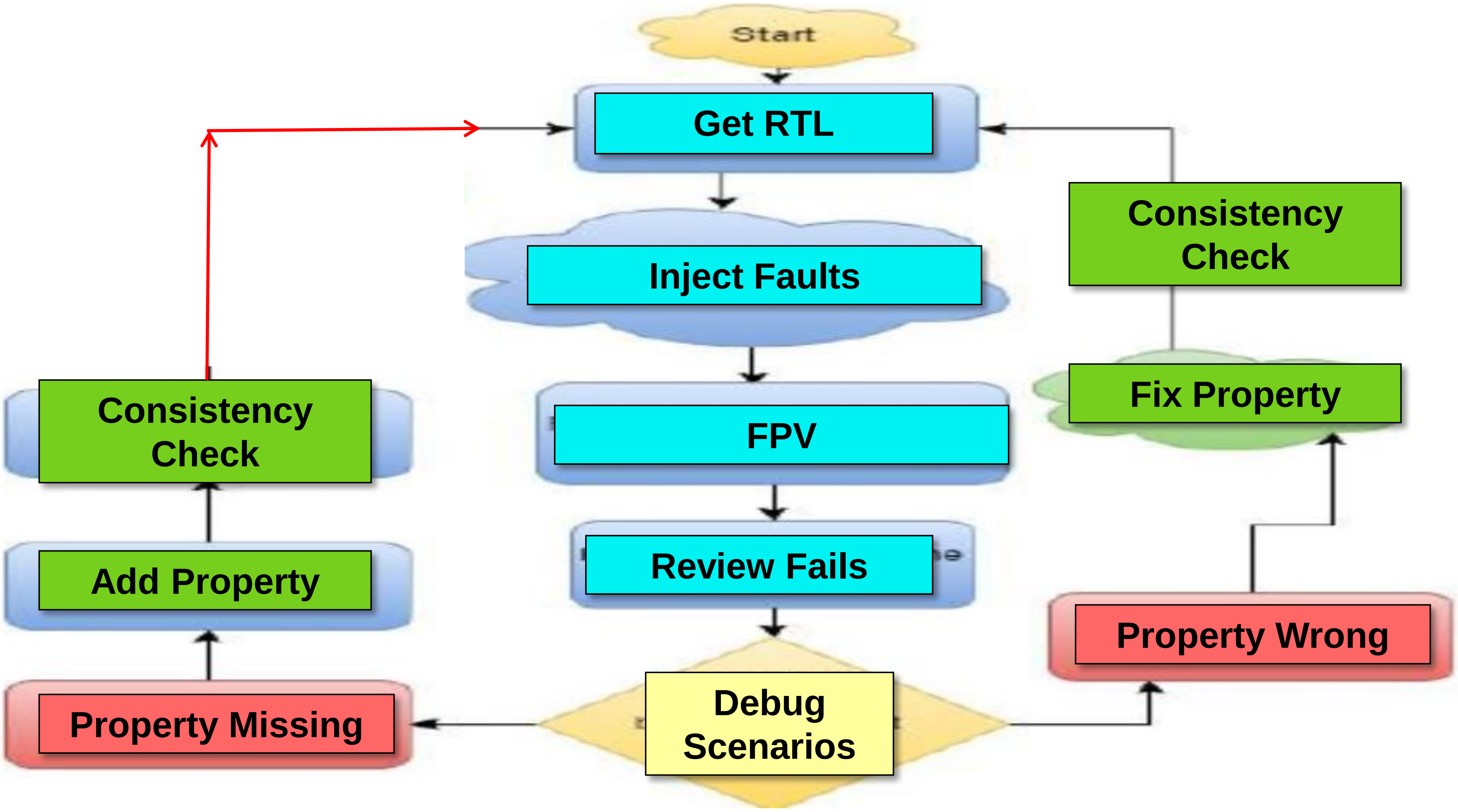
AGENDA

- Introduction: VIP & The 3 Cs
- Checking Consistency : Self-FPV
- Checking Completeness : Fault Injection + FPV
- Conclusions and Future Work

Fault Injection + Formal Property Verification

- Core intuition: ***Test the testbench***
- **Fault injection**: insert common faults in RTL + verify
  - Stuck-at, inversion, etc.
  - Does testbench detect the fault?
- Commonly used in simulation
  - Well-known solutions on market for years
  - Insert faults, check if simulation detects
- Use with Formal Property Verification less mature
  - But it's the same concept! (Sim checkers == FPV assertions)

The Fault Injection Flow



AGENDA

- Introduction: VIP & The 3 Cs
- Checking Consistency : Self-FPV
- Checking Completeness : Fault Injection + FPV
- Conclusions and Future Work

Completeness & Consistency: Do Both With FPV!

Completeness: Fault Injection + FPV	Consistency: FPV
Need one good RTL model	No RTL needed, just VIP
Focus == unchecked conditions	Focus == overconstraint
Discover new properties	Focus on written properties
Not available at early stages of VIP	Always available
Useful coverage measurement	Relies on hand-coded coverage
Very general– all classes of VIPs	Best for protocols/bridges

Issues Found

- Consistency: 2 bogus waveforms in protocol spec
  - Text not consistent with pictures, due to various edits since 1.0
  - Potentially major source of designer confusion
- Completeness: 1500+ faults injected
  - 140 “non-activated” or “non-detected”
  - Numerous behaviors not monitored in VIP: added assertions!
  - Some reset-related assertions not quite correct

Conclusions

- ***Consistency thru FPV: great for early VIP checking***
  - Very low cost since just requires light layer on VIP
  - Cover points (not just asserts/assumes) are important enabler
  - Can't address correctness or completeness
    - Don't be over-exuberant about 'FPV passing'
- ***Completeness thru fault injection + FPV: powerful followup***
  - Can't do early: need at least one RTL customer model
  - Finds critical omissions in VIP design
  - Finds holes in your user-written coverage
  - More usable than 'real' formal completeness

Future Work

- Flow Improvements
  - Injection of faults followed by FPV: a bit clunky
  - Opportunities for more integrated tools?
- Comparison of various forms of “Completeness”
  - Fault-injection : intuitively easy, straightforward debug
  - Formal coverage: possibly more powerful, usability improving
    - In practice, will these be redundant, or complimentary?
    - What about new, advanced tools?