Specification Reuse using Data Refinement in Dafny

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AGENDA

- INTRODUCTION
- PROBLEM STATEMENT/SOLUTION
- RELATED WORK
- IDENTIFYING PROGRAMMER OVERHEAD
- SOLUTION DESIGN
- IMPLEMENTATION
- PROOF OF CONCEPT
- EVALUATION
- CONCLUSIONS

INTRODUCTION

- Specifications
  - Set of client requirements
  - Formally expressed
    - Set theory
- Specifications Reuse
  - Changing the system internally
- Specification languages
  - Dafny, Spec#, JML and Eiffel.

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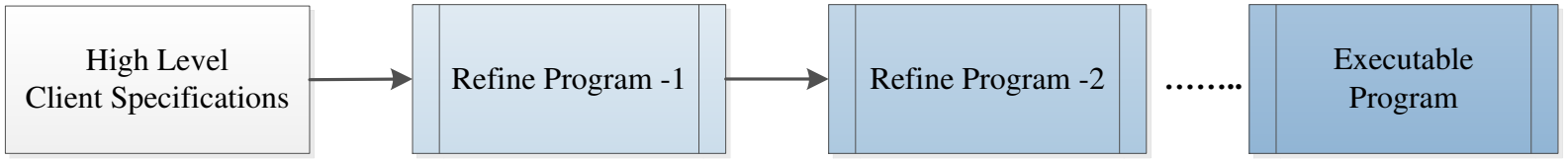
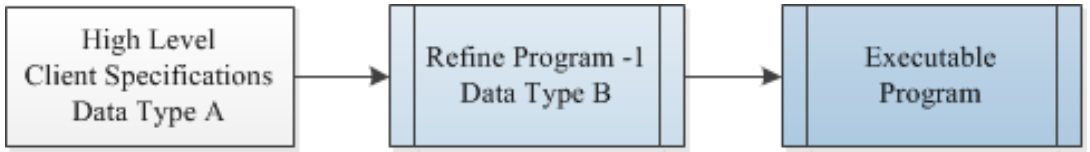
INTRODUCTION (Cont)

- Refinement



- Data Refinement



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PROBLEM DESCRIPTION

- Scenario's
  - Slow system performance
  - Multiple implementations
    - Regardless of any specific language
    - Differs in data structure
    - Specs in Sets
    - Implementation in arrays for Spec# and in link-list for Dafny

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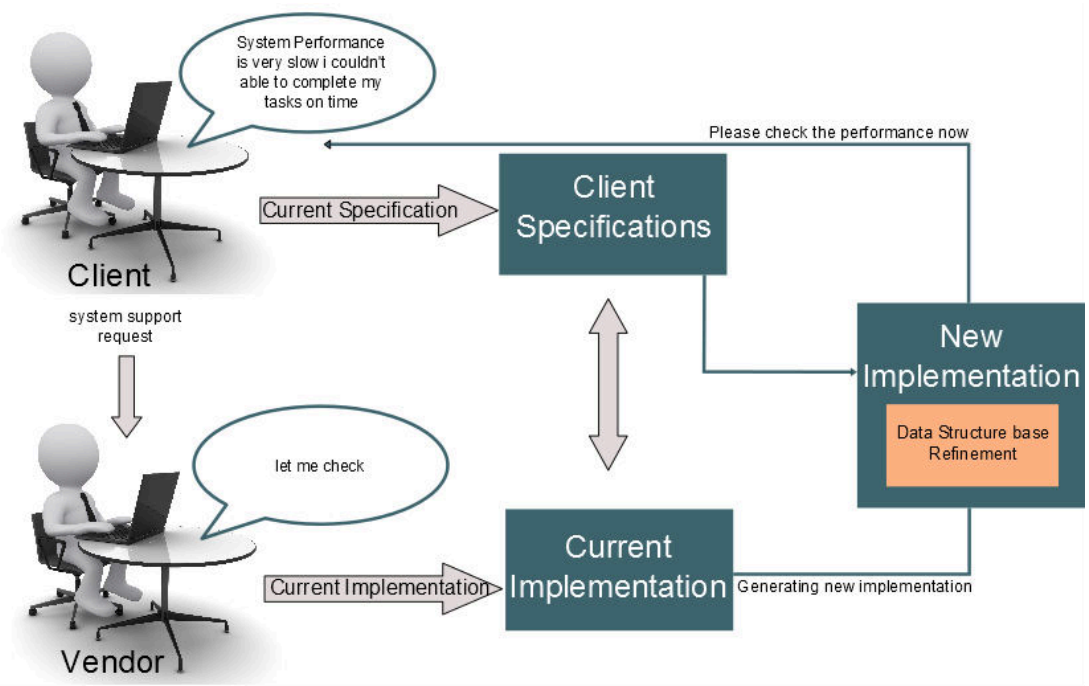
Solution

- Solution
  - Data Structure Based Data Refinement



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Solution (Cont)

- Goals of this research
  - Assisting programmers for reusing of specifications
  - Identifying programmers overhead for reusing specification manually
  - Proposing generic refinement framework based on data structure
  - Proof of Concept tool for data structure based Data refinement

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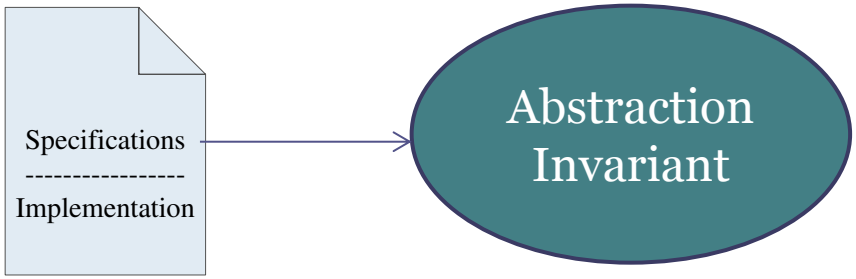
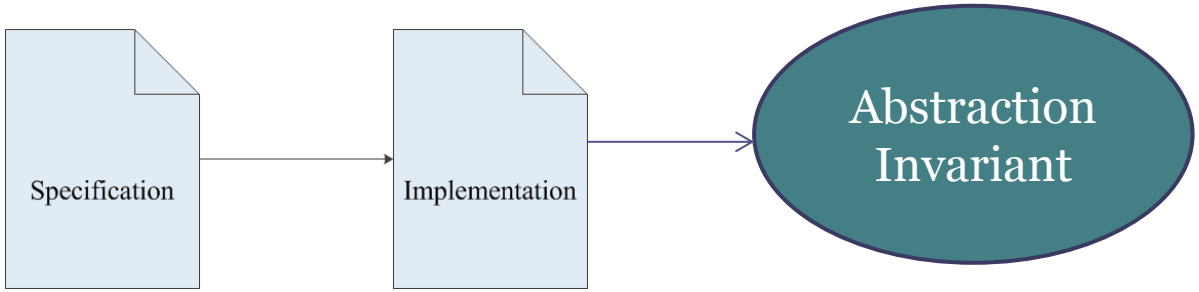
RELATED WORK

- Data Refinement in specification based languages
  - One class approach

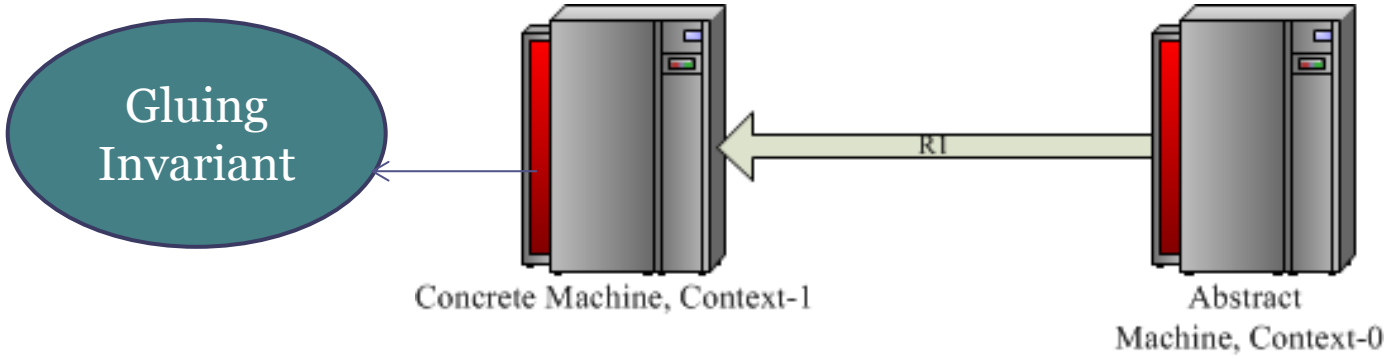


  - Two class approach



RELATED WORK (Cont)

- Data Refinement in Event-B
  - A modeling tool
  - Modeling is based on set theory
    - Contexts
    - Machines (Variables, Invariants and Events)



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Identifying Programmer Overhead

- Effort Calculation Metric
  - Modified COCOMO model
    - Organic, semi-detached, Embedded

Project Type	a	b	c	d
Organic/Small	3.2	1.05	2.5	0.38

Cost Driver	Rating		
	Low	Moderate	High
Verification attributes			
Verification Skills	1.25	1.00	0.75
Programming Language Knowledge	1.20	1.00	0.67

Cost Driver	Rating
Verification Type	
Manual	1.00
Automatic	0.20

Identifying Programmer Overhead (Cont)

Cost Driver	Rating
Data Structure used	
Sequence	0.05
Arrays	0.10
Link list	0.20
Tree	0.60

- Effort = a*(KLOC) ^b * EAF [man-months]
- Development Time = c*(KLOC) ^d [months]
- Total Days = Development Time * 30 [days]
- Persons Required = Effort/Development Time

  - Effort Adjustment Factor is the multiplication of all cost drivers according to the scenario

Identifying Programmer Overhead (Cont)

- High skills in verification and programming with automatic verification. The effort adjustment factor would be
- EAT = (0.75) * (0.67) * (0.20) * (data structure to be used rating)

Specification	Data Structures	KLOC	Implementation and Verification effort in term of DT
Sequence/Set	Sequence	500 => 0.5	12 days
Sequence/Set	Link-list	500 => 0.5	20 days
Sequence/Set	Arrays	500 => 0.5	15 days
Sequence/Set	Tree	500=> 0.5	30 days

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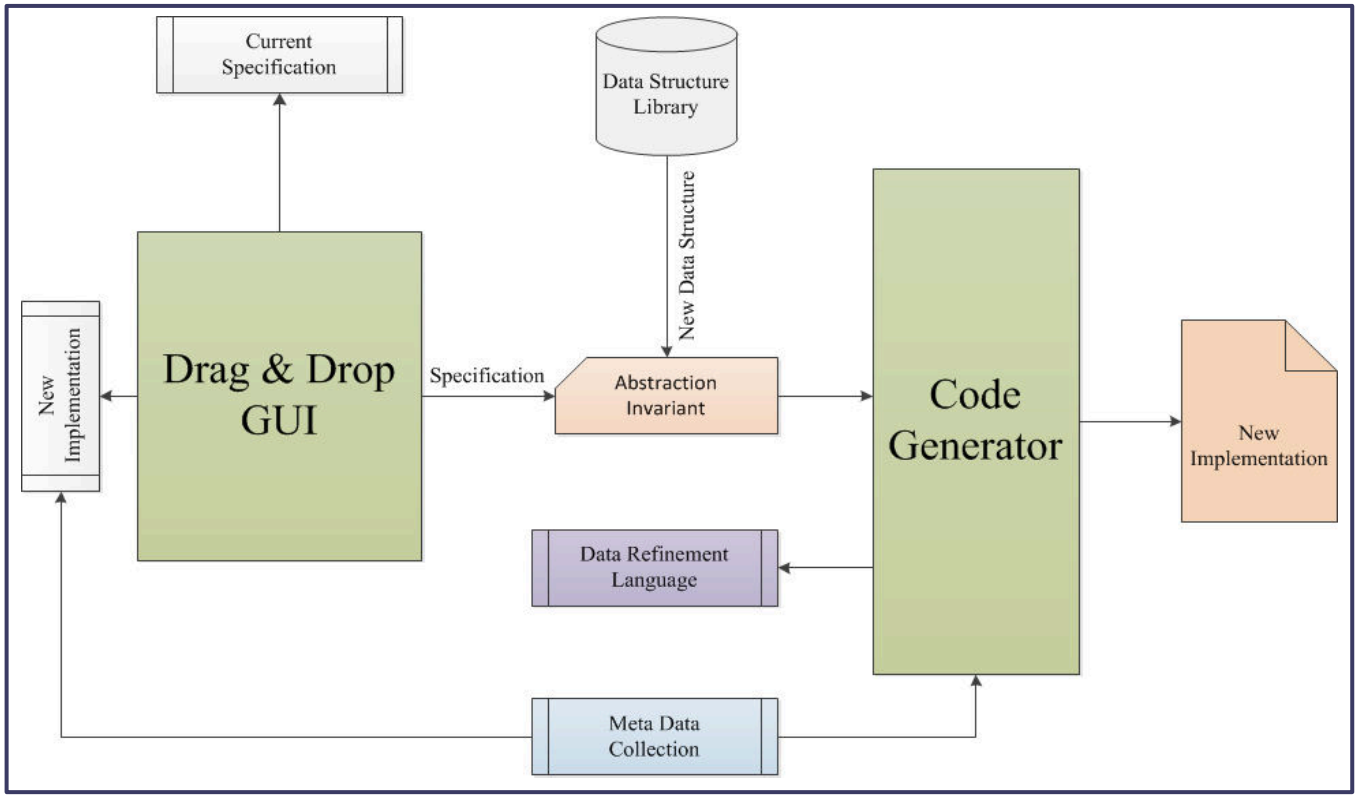
SOLUTION DESIGN

- Proposed Architecture



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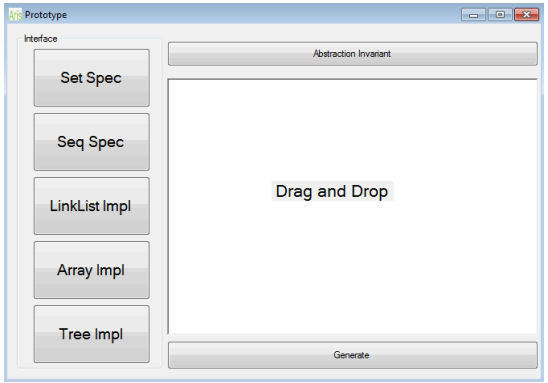
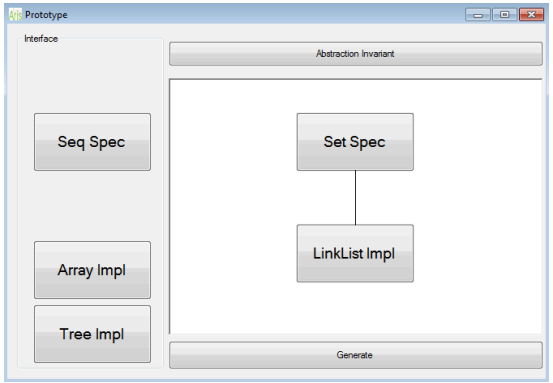
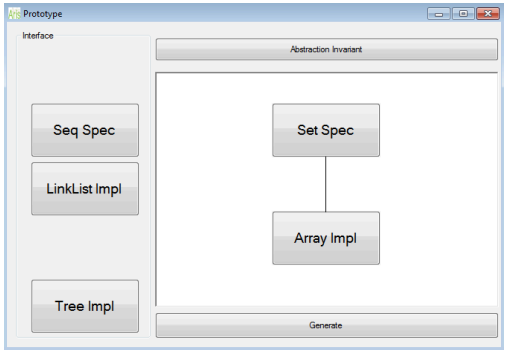
SOLUTION DESIGN (Cont)

- Interface Design







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IMPLEMENTATION

- Issues for implementing ideal design
  - Unavailability of external data structure library
  - Lack of external data refinement language
  - Lack of support for meta data collection
- Dafny
  - Support data refinement

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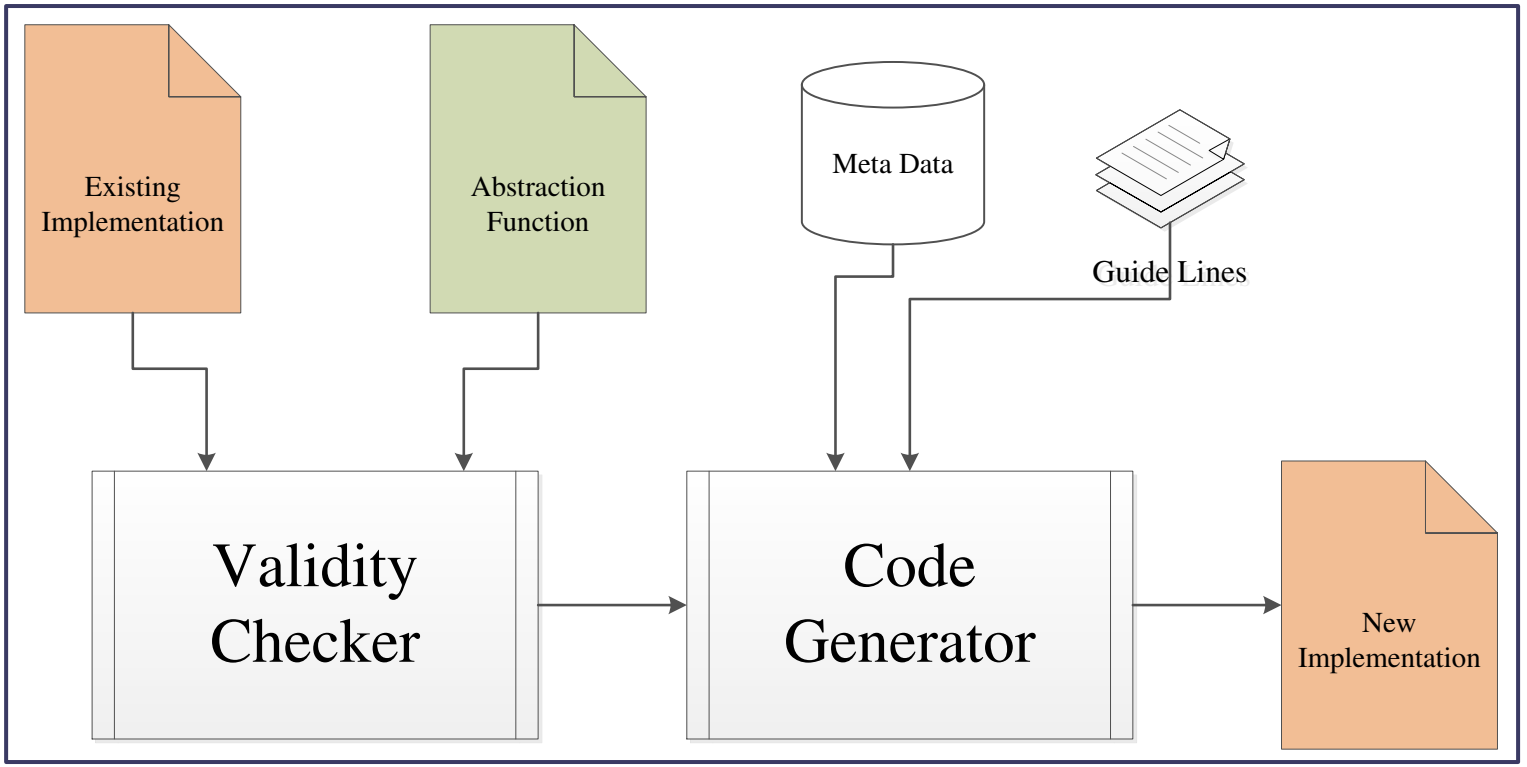
IMPLEMENTATION (Cont)

- Specification Reuser



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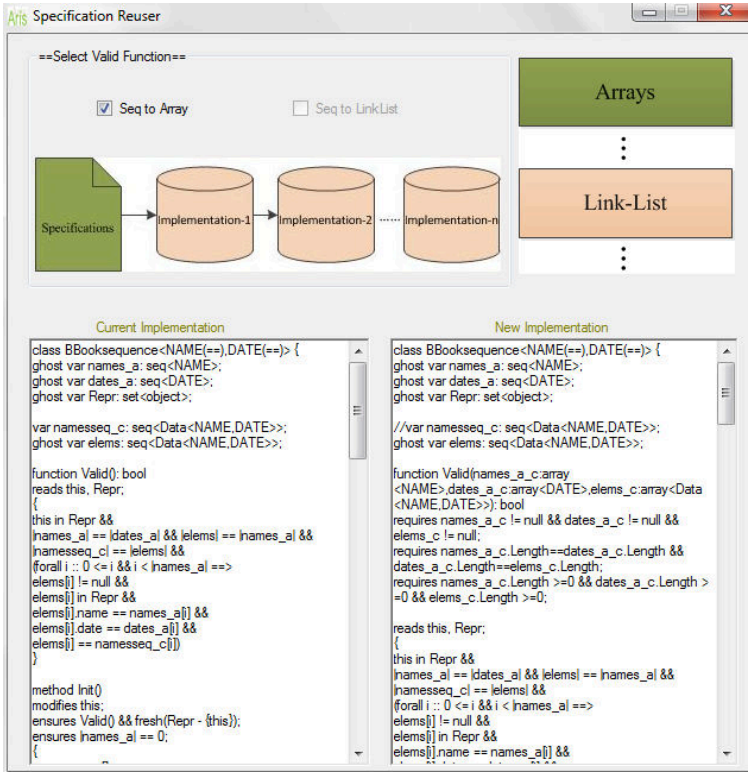
PROOF OF CONCEPT

- Birthday's recording system
  - Add birthday
  - Find birthday
  - Remind birthday



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EVALUATION

- Criteria
  - Automation
  - Verification
  - Effort Reduction

EVALUATION (Cont)

- Evaluation

Specifications	Data Structure	Generation	Comments
Sequence	Arrays	Automatic	Specification is in term of a sequence and implementation is in term of arrays
Sequence	Link List	Automatic	Specifications is in term of a sequence and implementation is in term of link list

- Validation

Specifications	Data Structure	Generation	verified
Sequence	Arrays	Automatic	Yes
Sequence	Link List	Automatic	Yes

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EVALUATION (Cont)

- Results

Specification	Data Structures	KLOC	Implementation and Verification effort in term of DT
Sequence/Set	Sequence	500 => 0.5	12 days
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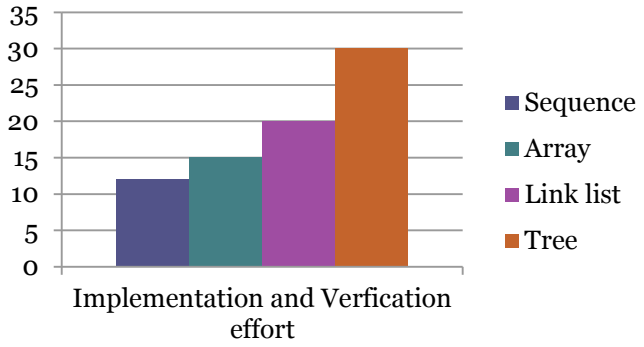
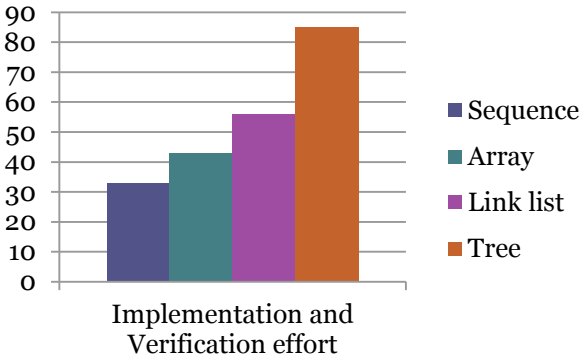
Sequence/Set	Tree	500=> 0.5	30 days



Specification	Data Structures	KLOC	Implementation and Verification effort in term of DT
Sequence/Set	Sequence	500 => 0.5	33 days
Sequence/Set	Link-list	500 => 0.5	56 days
Sequence/Set	Arrays	500 => 0.5	43 days
Sequence/Set	Tree	500=> 0.5	85 days



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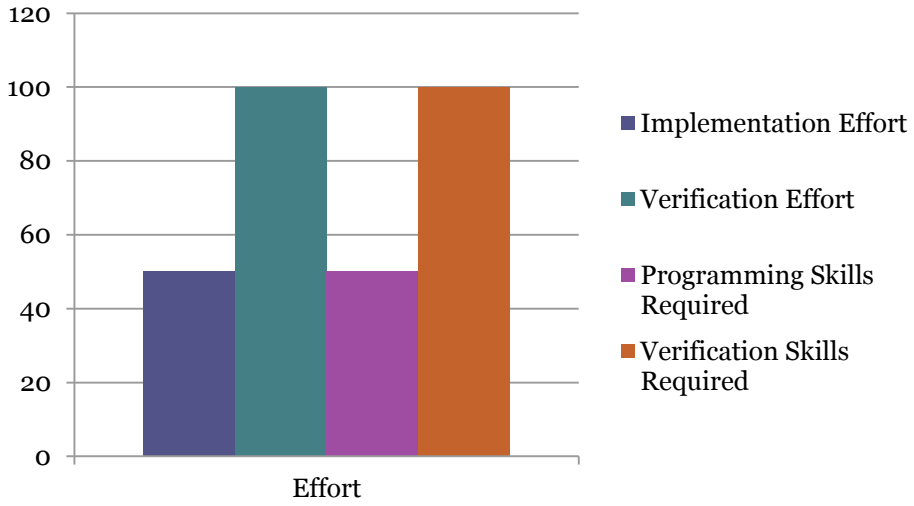
EVALUATION (Cont)

Specification	Data Structure	KLOC	Implementation effort	Verification effort	Programming Skills	Verification Skills
Sequence	Arrays	Doesn't matter	Low	Moderate	Low	Moderate
Sequence	Link-list	Doesn't matter	Low	Moderate	Low	Moderate



EVALUATION (Cont)

- Critical Analysis
  - Effort Metric
    - Specific to specification based languages such as Spec# and Dafny
    - Providing rough estimation
  - Genericity
    - For small programs : 70-90%

EVALUATION (Cont)

- Verification
  - For small programs : 70-90%

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CONCLUSIONS

- Summary
  - Proposed generic refinement framework
  - Modify the cost drivers of the COCOMO model
  - Calculated programmer overhead
  - Developed POC tool for data structure based Data Refinement

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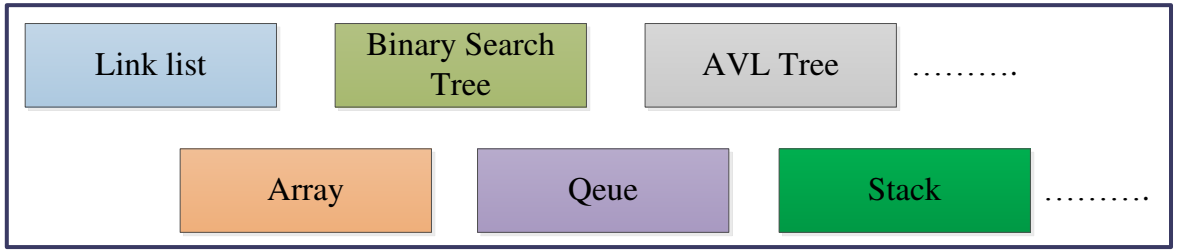
CONCLUSIONS (Cont)

- Future Work
  - Library development



  - Language Development
  - Meta Data Collection
  - Improved GUI
  - Full Danfy tool Implementation

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Thanks for Listening!

Q&A