Optimizing Cycle Time Through the Use of Metrics

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Agenda

- Historical perspective
- Growing interest
- Collection process
- Analysis process
- Examples/Results
- Conclusions
- Future Direction

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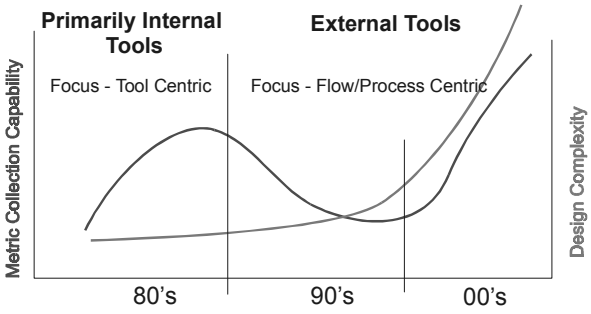
Historical View on Metrics



Purpose
Usage Tracking
Feature Tracking
Quality Tracking

Primary User
Tool Developer

Purpose
Cycle Time
Productivity
Process Improvement

Primary User
Design Managers
EDA Managers

Renewed Interest – Why?

- Design size and complexity
- Time to market critical
- No one person understands the whole flow
- Difficult to optimize – improving one step can lead to poor results in another step
- Hard to improve if you don't know what to focus on.
- Expensive to get information from data
- Difficult to justify major changes without facts
- Hard to set goals for improvement when you can't measure progress

Metrics Collection - Goals

- Make it easy to get information about design flow not just tool usage data
- Get metrics as close to real-time as possible
- Develop methods to mine data for information
- Drive to get key cycle time improvement opportunities implemented

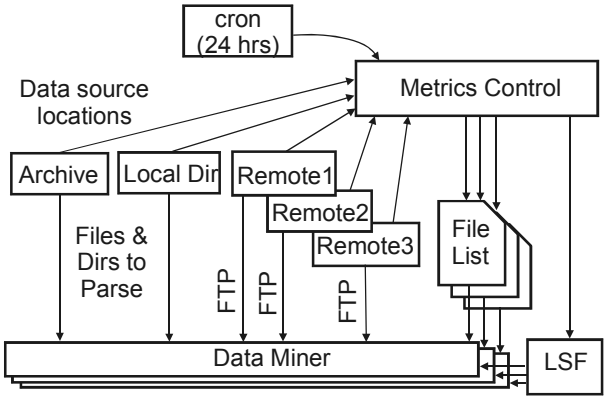
Metrics Collection Requirements

- Use existing infrastructure to collect metrics – no major development to change system
- Must be able to collect metrics from most design centers
- Initial focus is on physical design portion of the flow
- Have data on completed designs and designs in progress
- Data should be current to the last 24 hours

Metrics Collection Programs

- Metrics Control Program
  - Determines all the possible files and directories that need to be analyzed
  - Creates many file/dirs lists that get submitted to data mining program (via LSF) to be analyzed
- Data Mining
  - Determines if a file/dir has changed (via the timestamp) since last time and, if so, parses the file again and adds/updates the Oracle database

Centralized Metrics Collection Flow



Oracle Metrics Tables

- Designs Table – List of designs
- Details Table – Lists of design attributes
- Steps Table – List of steps executed in flow
- Macros Table – List of macros (cells, I/Os, macros, and subchips) used in the design
- MacroSize – List of sizes of macros
- File_Stats – Last timestamp of listing file

Data Collection

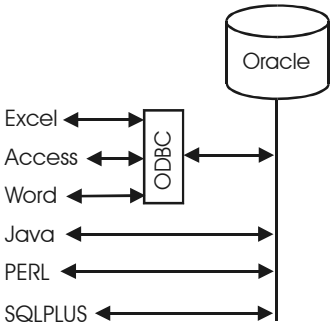
- Question - Collect everything or collect what you think you can use?
- Currently collect what we think we can use
- Archive text reports from design – can process text files again to add more data to database

Metrics Collection Issues

- The physical design process was not designed with metrics collection in mind
- Not all data available that you would like to have
- Missing designs since there is not 100% coverage from the collection process
- Some data about a design is missing since there is no checking to make sure it exists
- Common way to collect/save data when several different layout tools are used (Apollo, Astro, Magma, PC)

Metrics Analysis Options

- Many different ways to access Oracle
- PERL, C++, JAVA, SQLPLUS, EXCEL, ACCESS, WORD, STAROFFICE…
- Different scripts/programs developed to look at specific issues
- No one analysis program can do it all
- Web interface required for basic visibility into metrics



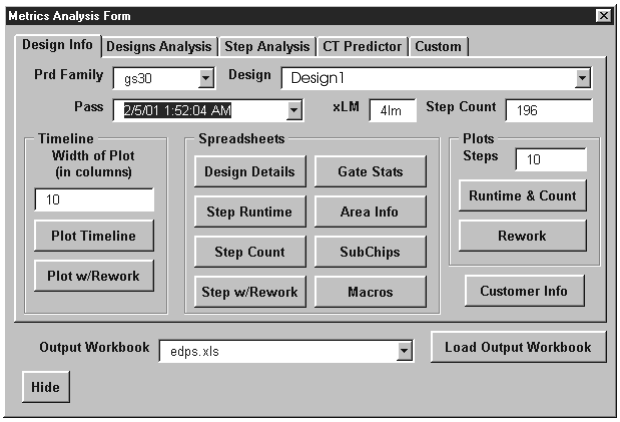
Excel Interface to the Metrics

- Example of how to analyze metrics
- Excel 2000 spreadsheet to used to analyze metrics
- Why Excel – good graphing, VBA, easily available
- Can be easily extended/changed by the user

Analysis Methods

- A single design – select design
- Collection of Designs – Defined by a Design List spreadsheet
- Collection of Steps – Defined by a Design List spreadsheet
- Each design pass (i.e. ECO cycle) is considered a separate use of the flow

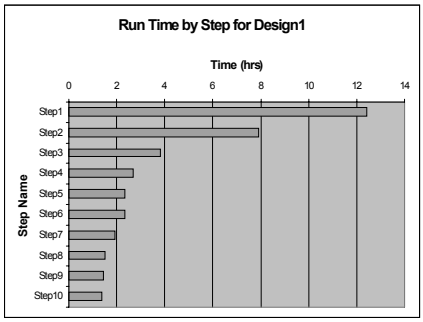
Form to Access Metrics

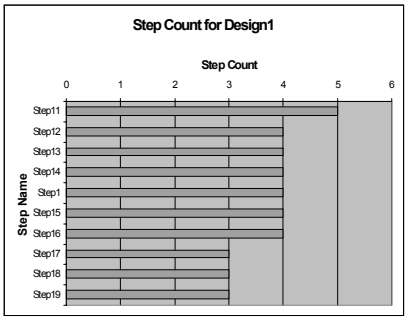


Example Flow Execution

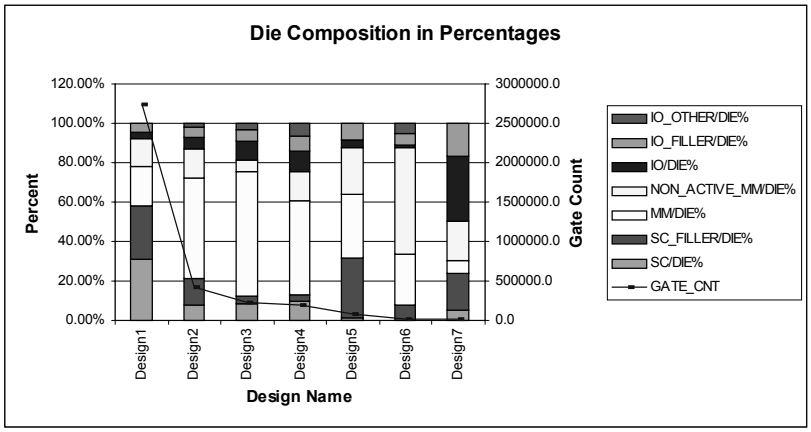
	A	B	C	D	E	F	G
1	Step-Tot Days= 8.47, UnRecorded Time-Wht space(days) 6.45, Recycle time (days)= 1.82						
2	Step Name	Time(hrs)					
3	Step1 (1)	0.319					
4	Step2 (1)	0.001					
5	Step3 (1)	0.156					
6	Step4 (1)	0.016					
7	Step5 (1)	0.188					
8	Step6 (1)	0.164					
9	Step7 (1)	0.018					
10	Step8 (1)	0.001					
11	Step9 (5)	0.761					
12	Step10 (4)	0.157					
13	Step11 (4)	0.017					
14	Step12 (4)	0.013					
15	Step13 (4)	0.041					
16	Step14 (3)	0.113					
17	Step15 (3)	0.170					
18	Step16 (3)	0.301					
19	Step17 (4)	1.428					
20	Step18 (2)	0.033					
21	Step19 (2)	0.001					
22	Step20 (2)	0.024					

Design Run Time/Run Count

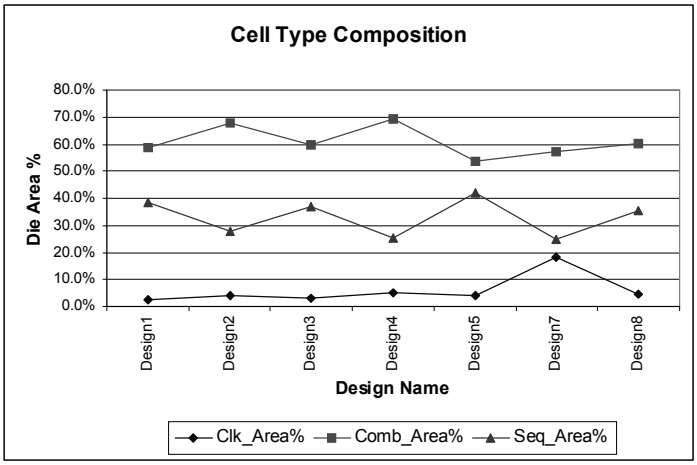




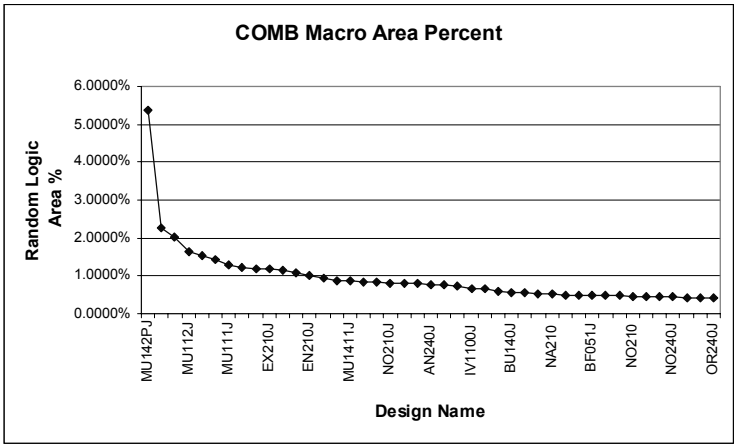
Example Die Composition



Example Cell Type Composition



Example – Cell Area %



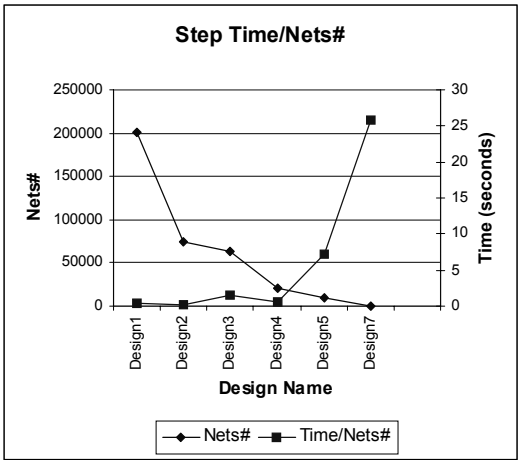
Runtime for Several Designs

	A	B	C	D	E	F
1	StepName (Designs = 7)	TotalTime	TotStepCnt	MinTime	MaxTime	AvgTime/Run
2	Step1	125.1	12	0.011	83.399	10.424
3	Step2	100.5	10	0.042	44.227	10.048
4	Step3	82.8	10	0.217	23.073	8.280
5	Step4	73.2	29	0.001	16.276	2.524
6	Step5	46.6	52	0.003	3.795	0.896
7	Step6	46.5	91	0.003	7.852	0.510
8	Step7	35.2	17	0.121	10.690	2.070
9	Step8	34.9	29	0.001	3.412	1.203
10	Step9	31.2	26	0.002	7.346	1.198
11	Step10	29.8	24	0.001	10.352	1.242
12	Step11	28.2	28	0.006	3.311	1.006
13	Step12	27.5	36	0.001	4.431	0.764
14	Step13	27.3	36	0.001	4.060	0.759
15	Step14	21.4	10	0.013	8.512	2.139

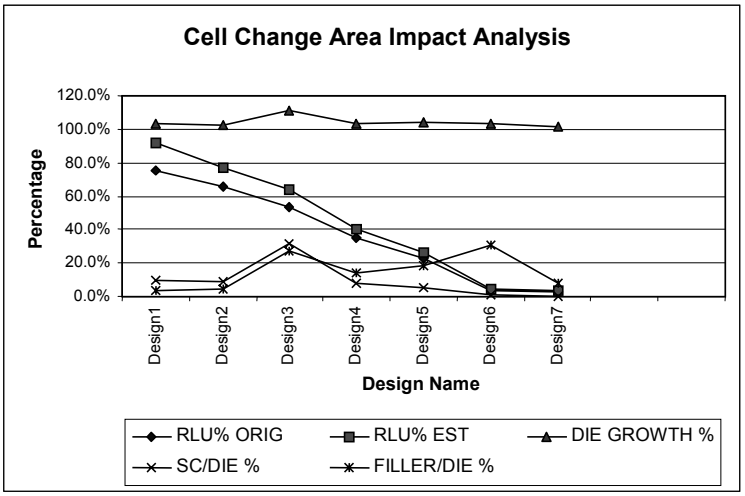
Step Recycle Summary

1	Design	(All)							
2									
3			From						
4	To	Data	Step7	Step8	Step9	Step10	Step11	Step12	Grand Total
5	Step1	Sum of Duration			136.05				136.05
6		Sum of RepeatSteps			54				54
7		Count of From			1				1
8	Step2	Sum of Duration						60.25	60.25
9		Sum of RepeatSteps						34	34
10		Count of From						2	2
11	Step3	Sum of Duration				0.05	26.28		26.33
12		Sum of RepeatSteps				1	15		16
13		Count of From				1	1		2
14	Step4	Sum of Duration	111.14						111.14
15		Sum of RepeatSteps	24						24
16		Count of From	1						1
17	Step5	Sum of Duration		146.70					146.70
18		Sum of RepeatSteps		31					31
19		Count of From		3					3
20	Step6	Sum of Duration				0.01	291.61		291.62
21		Sum of RepeatSteps				1	74		75
22		Count of From				1	5		6
23	Total Sum of Duration		111.14	146.70	136.05	0.06	317.89	60.25	772.09
24	Total Sum of RepeatSteps		24	31	54	2	89	34	234
25	Total Count of From		1	3	1	2	6	2	15

Step Time per Design Attribute



Cell Change Area Impact

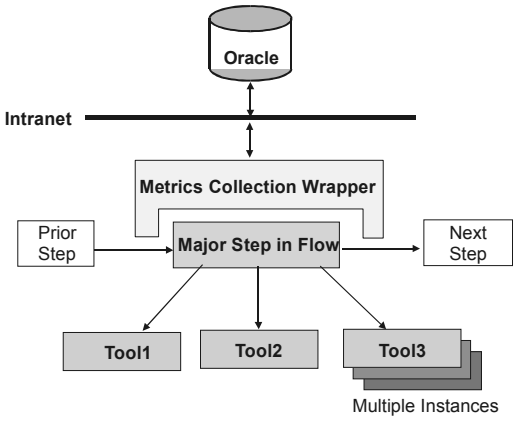


Types of Cycle Time Improvements

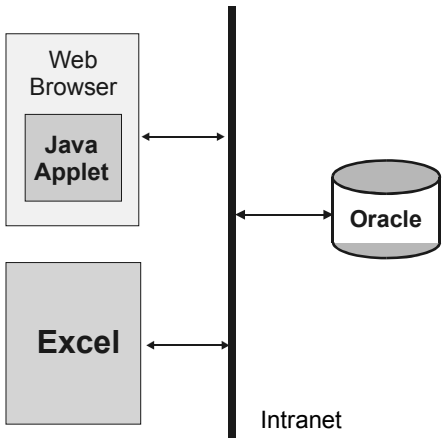
- Steps being run in the flow when no input data was changed
- Improved ordering for steps in the flow (reduce time when there are recycle loops)
- Checks being run too late in the flow. Difficult to make changes to fix problem
- Checks being run too early in the flow. Design is not solid enough so no action is being taken with the output
- Too much layout database extraction/conversion time
- Opportunities for parallelism in the flow not exploited
- ASIC architecture causing S/W to be overly complex/slow
- Poor input data quality causing recycle loops
- Improved algorithms for handling larger data volumes

Future Collection Direction

Local Data Collection



Future Analysis Direction



Conclusions

- Lots of ways to use metrics – scratched the surface.
  - Amazed on number of ways to apply metrics
- A majority of the major cycle time issues not tool problems but flow and process problems
- Can help drive changes in the flow
- Knowing the flow can be measured creates different behavior
- Harder than you think to formulate a good question
- Contagious - having some metrics capability drives additional interest
- Must drive to have metrics used in continuous improvement process
- Move up from cycle time improvements to productivity improvements