Predicting Performance of Micropipelines using Charlie Diagrams

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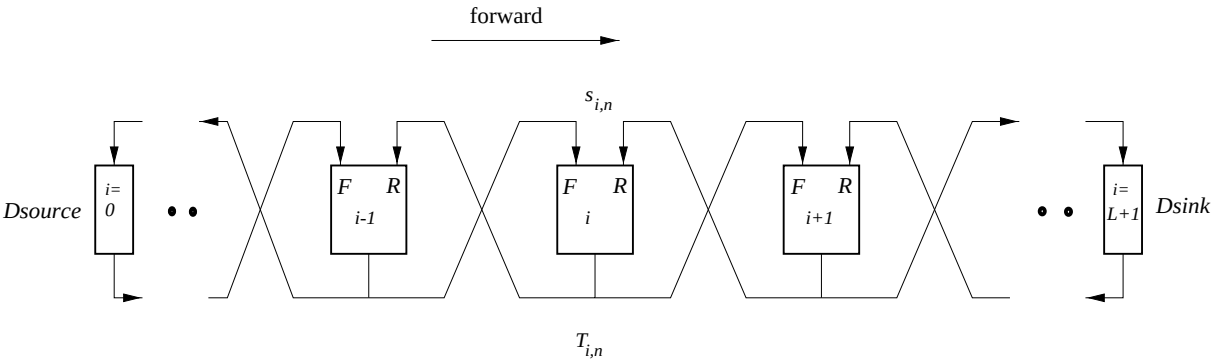
The Problem

- General structure of a Micropipeline:
  Chain of RendezVous Elements

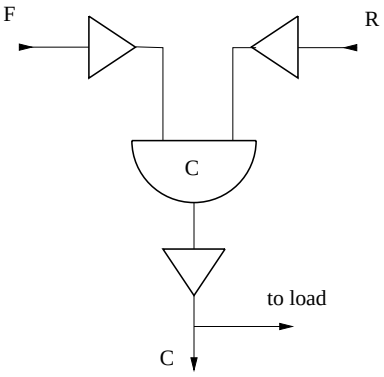


- How to obtain an accurate performance prediction?
- Cycle time as function of
  - RendezVous implementation
  - Length of pipeline
  - Source delay
  - Sink delay
- Transient and steady-state behavior
- SPICE is too time consuming

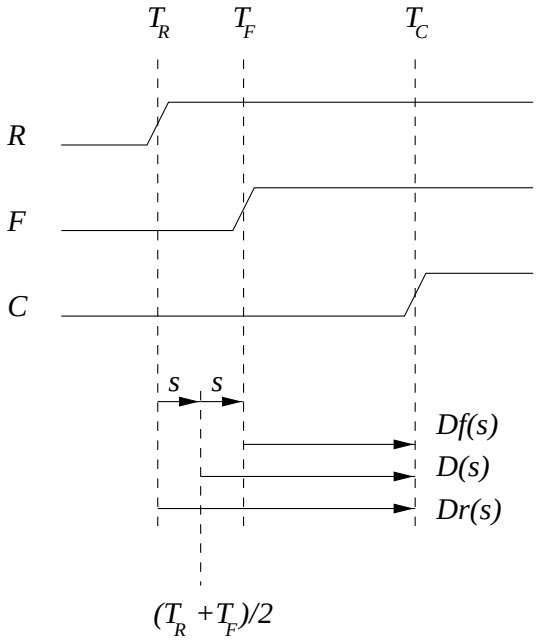
Related Work

- Ted Williams
  Fixed Delay Model
  Predicts throughput vs fullness of rings
- Hulgaard et al., Ebergen&Berks
  Variable (interval) delay model
  worst-case time separation
- Greenstreet & Steiglitz, Xie & Beerel
  Probabilistic delay models
  average cycle time
- Do not explain certain phenomena or
  Not accurate enough

The RendezVous Element and Its Delays

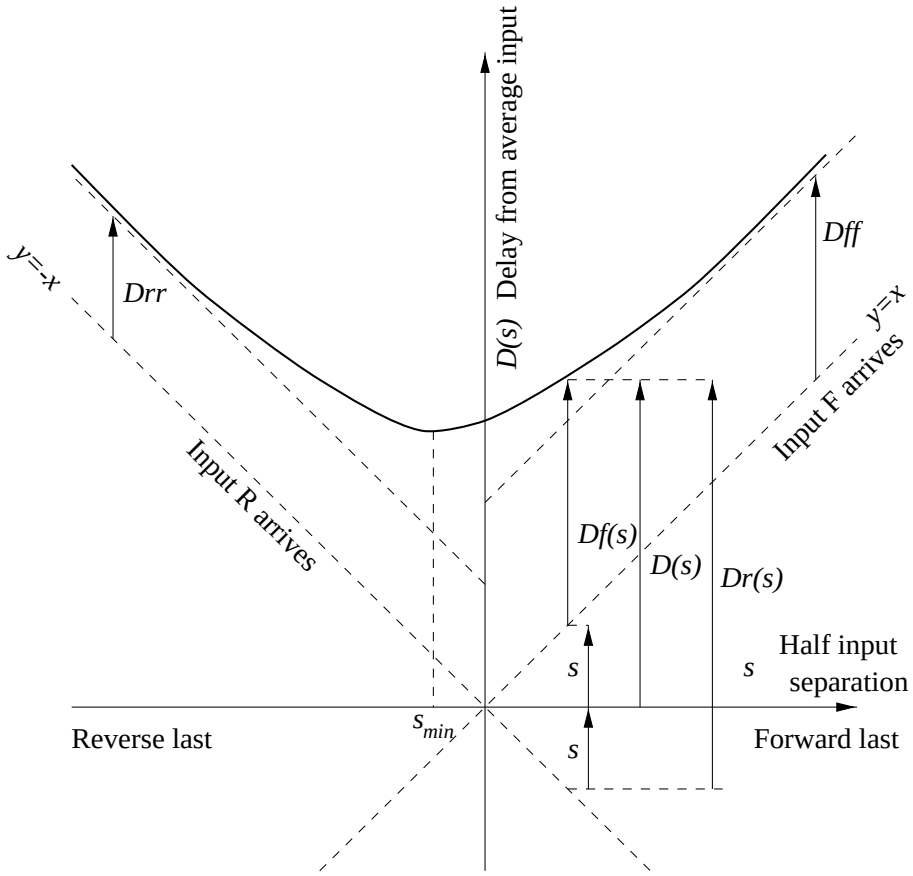


General Implementation



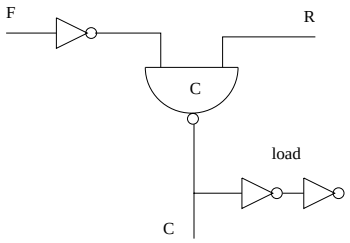
Timing Diagram

The Charlie Diagram

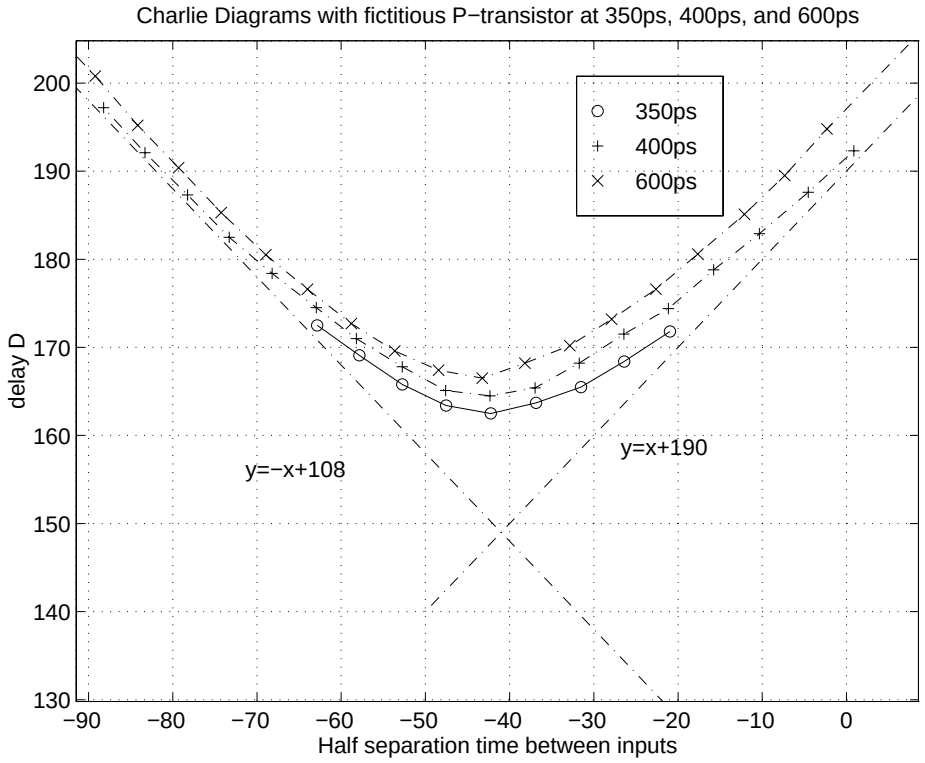


Actual Charlie Diagrams

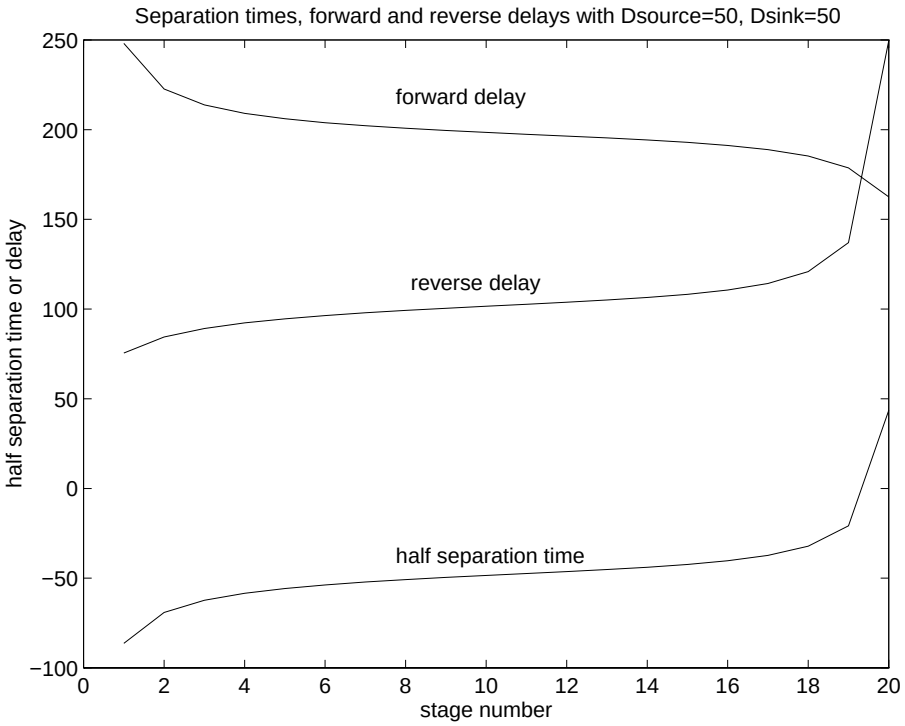
- Implementation:



- Charlie Diagram:

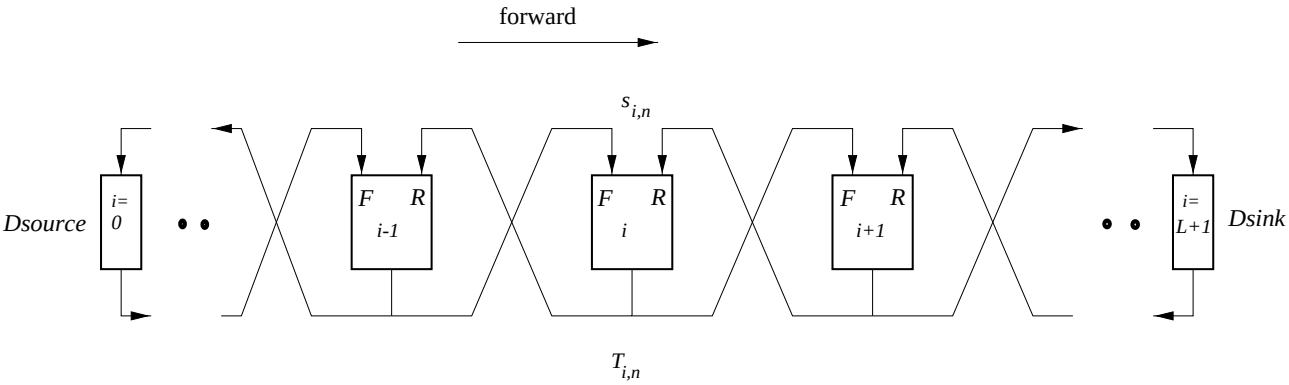


Separation Times and Delays



An Analysis

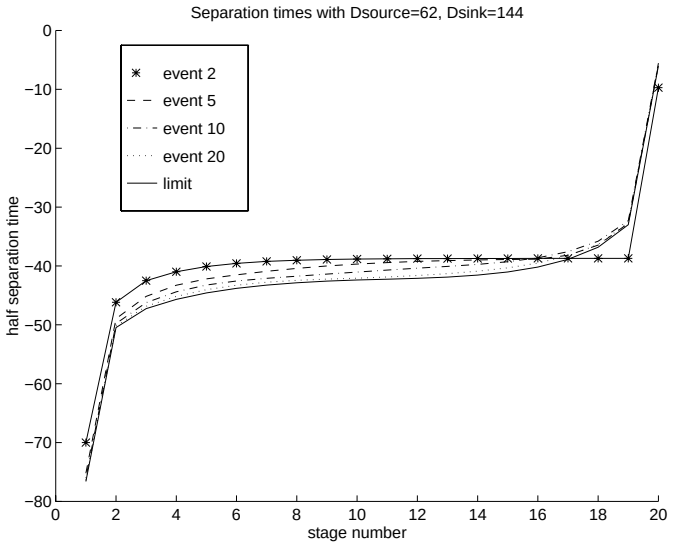
- The Chain of RendezVous Elements:



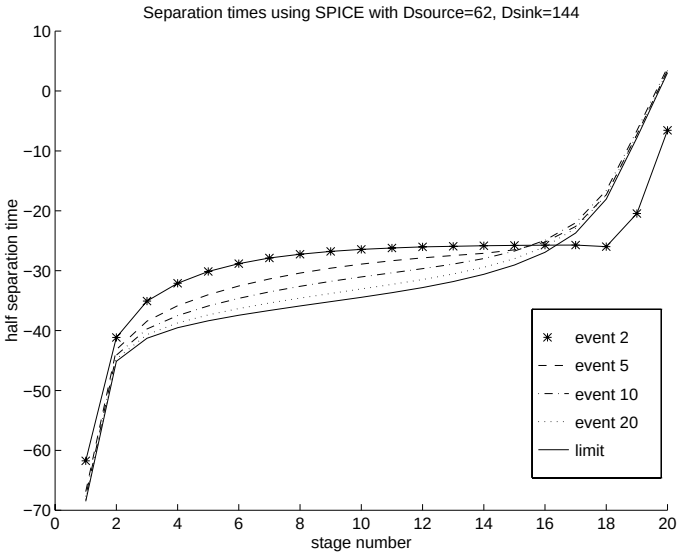
- The difference equations:

$$
\begin{aligned}
s_{i,0} &= +\infty \quad \text{for } 1 \leq i \leq L \\
Dsource - Df(s_{2,n}) &= 2 * s_{1,n+1} \\
Dr(s_{i-1,n+1}) - Df(s_{i+1,n}) &= 2 * s_{i,n+1} \quad \text{for } 1 < i < L \\
Dr(s_{L-1,n+1}) - Dsink &= 2 * s_{L,n+1}
\end{aligned}
$$

Self-Limited Pipelines

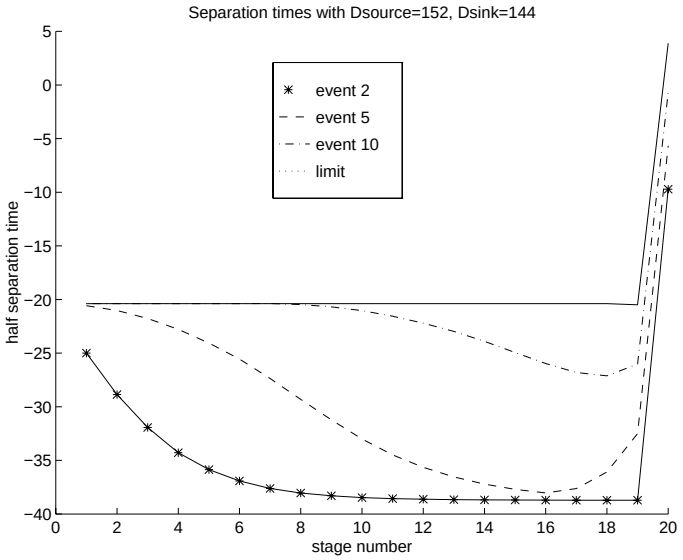


(a) With Charlie diagram

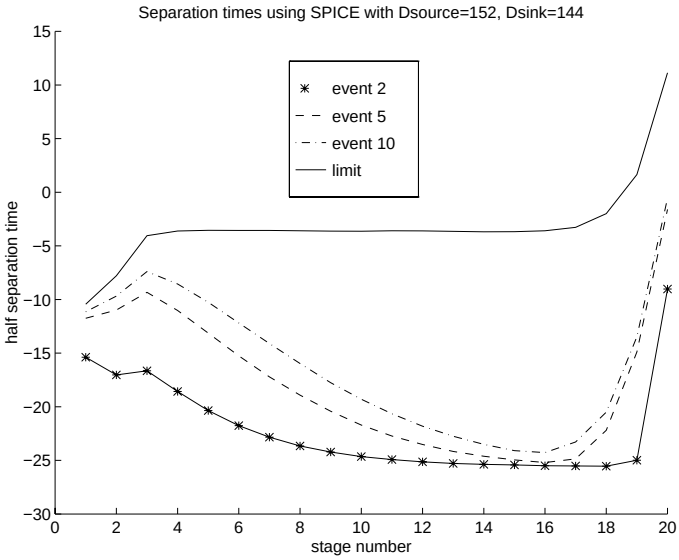


(b) With SPICE

Source-Limited Pipelines

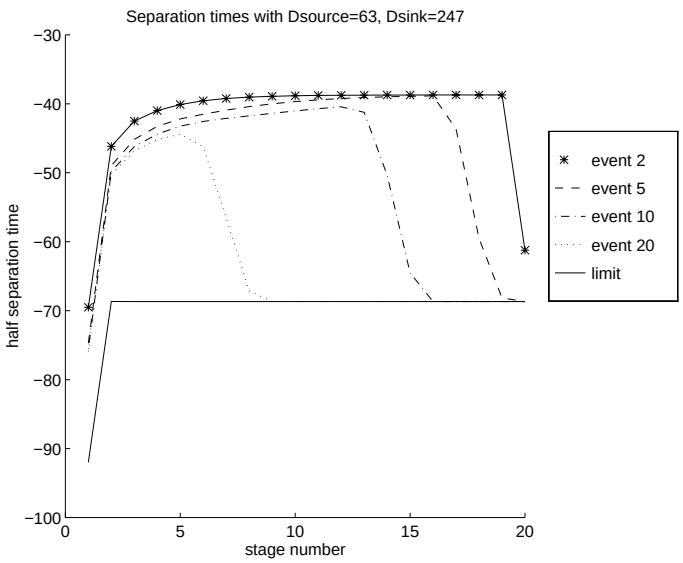


(a) With Charlie diagram

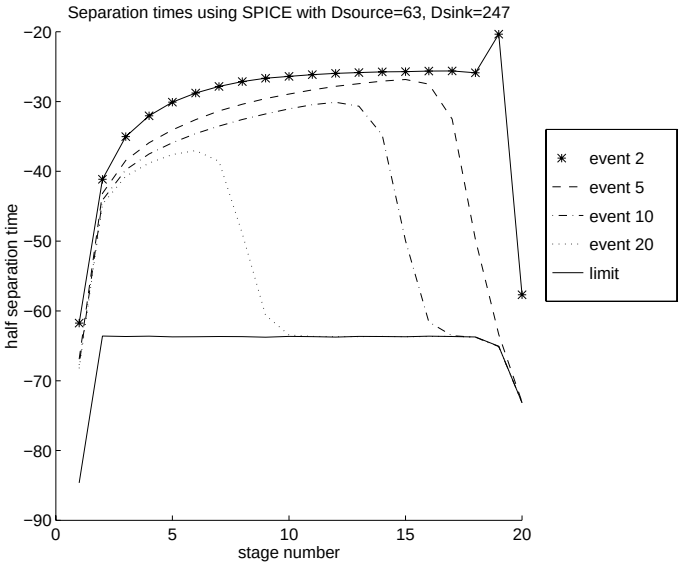


(b) With SPICE

Sink-Limited Pipelines



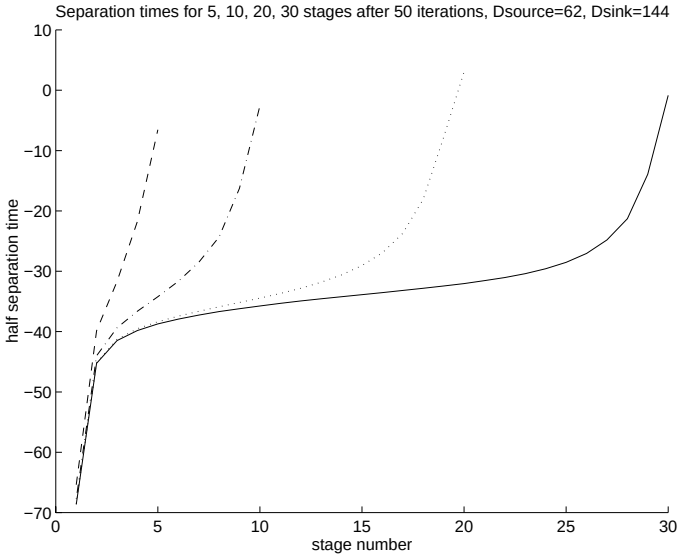
(a) With Charlie diagram



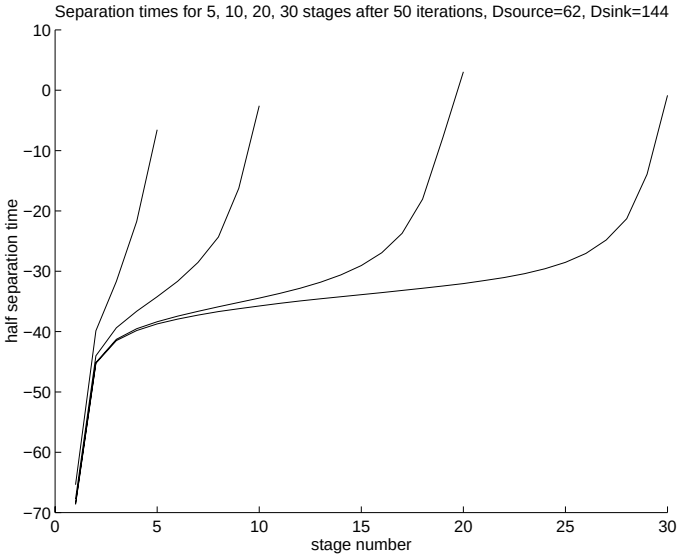
(b) With SPICE

Effect of Length

Self-Limited pipelines with $L = 5$, 10, 20 and 30 stages.



(a) With Charlie diagram



(b) With SPICE

Concluding Remarks

- Are Charlie Diagrams applicable to other areas?
- Cycle time and Charlie Diagrams
- Generalizing Charlie Diagrams?