ECE 695R: System-on-Chip Design

Module 4: On-chip Communication Architecture
Lecture 4.9: Arbitration Techniques - LOTTERYBUS

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Lottery-Based Protocol

- Flexible bandwidth allocation (like TDMA)
- Low latency for critical communications (like static priority)

LOTTERYBUS Algorithm

- \( N = \) number of tickets in current lottery
- Generate \( t \) at random from \((0, N-1)\)
- Grant master which “owns” ticket \( t \)

- Probabilistically guaranteed bandwidth
- Asymptotically bounded latency

\[
\begin{align*}
\text{t}_1 &= 1 \\
\text{t}_2 &= 2 \\
\text{t}_3 &= 3 \\
\text{t}_4 &= 4 \\
C_1 &\rightarrow \text{R}_1 = 1 \\
C_2 &\rightarrow \text{R}_2 = 0 \\
C_3 &\rightarrow \text{R}_3 = 1 \\
C_4 &\rightarrow \text{R}_4 = 1 \\
\text{T}[0] &= C_1 \\
\text{T}[1] &= C_3 \\
\text{T}[2] &= C_3 \\
\text{T}[3] &= C_3 \\
\text{T}[4] &= C_4 \\
\text{T}[5] &= C_4 \\
\text{T}[6] &= C_4 \\
\text{T}[7] &= C_4 \\
\text{T}[8] &= \text{XX} \\
\text{T}[9] &= \text{XX} \\
\text{Gnt}_4 &= 1
\end{align*}
\]

Probability of First Win

Lottery Number

Graph showing probability of first win against lottery number for different winning percentages.
Hardware Implementation (Statically Assigned Tickets)

- Static: LUTs store pre-computed ticket ranges, mask
- Ensuring that total tickets is a power of 2 simplifies RNG
- Worst case arbitration delay 3.2 ns (312.5Mhz, 0.35 um NEC lib)
LOTTERYBUS: Bandwidth Allocation

- Experimental study: 4 master, 4 slave system with random traffic resulting in high bus utilization (ticket holdings: 1, 2, 3, 4)
  - Objective: measure bandwidth received by each master

- Bandwidth allocation respects ticket allocations (10%, 20%, 30%, 40%),

- No component starves

Ticket Assignments to C1-C4 (4=hi, 1=lo)

Bandwidth allocation respects ticket allocations (10%, 20%, 30%, 40%).