Appendix A

Simulation Results for Throughput at Saturation

Crossbar Networks

The simulation results for the throughput at saturation of the various switch fabrics are presented in this appendix to enable the comparison of the different switch structures. Table A.1 presents the results for the crossbar switch fabric with blocked packets resubmitted both for synchronous operation and for asynchronous operation with a retry delay of 10% of the packet length. The synchronous and asynchronous results for the regular structure (pure input buffered with no queue by-pass or output buffering) are plotted in fig. 6.1.

Size	Synchronous		Asynchronous (10% retry delay)			
	Regular	Double Buffer	Regular	Queue By-Pass	Double Buffer	De-Luxe
2	.747	1.0	.742	.878	1.0	1.0
4	.650	.941	.640	.808	.931	.981
8	.613	.916	.601	.771	.897	.971
16	.594	.905	.583	.752	.883	.965
32	.586	.900	.575	.746	.876	.961
64	.585	.898	.572	.740	.872	.958
128	.585	.896	.572	.740	.872	.957
256	.584	.896	.572	.739	.872	.954
512+	.585	.896	.572	.739	.872	.951

Table A.1: Throughput at saturation for crossbar switch fabrics.

Delta Networks with a Searching Algorithm

Tables A.2 to A.5 give the throughput at saturation of delta networks constructed from switching elements of degree 2 to degree 16 with a searching algorithm and a retry delay of 10% of the packet length. These results derive from the simple model, the accuracy of which is presented in tables 6.2 and 6.3.

Size	Single Plane		Two-Plane			
	Regular	Queue By-Pass	Regular	Queue By-Pass	Double Buffer	De-Luxe
2	.742	.878	.740	.879	.975	.971
4	.597	.791	.639	.799	.895	.930
8	.517	.711	.598	.742	.817	.885
16	.462	.642	.566	.705	.755	.839
32	.423	.583	.547	.672	.703	.795
64	.392	.536	.532	.648	.662	.756
128	.366	.496	.515	.622	.624	.719
256	.344	.463	.502	.599	.593	.684
512	.325	.435	.484	.577	.564	.654

Table A.2: Throughput at saturation of delta networks with switching elements of degree 2 for a searching algorithm.

Size	Single Plane		Two-Plane			
	Regular	Queue By-Pass	Regular	Queue By-Pass	Double Buffer	De-Luxe
4	.640	.808	.645	.813	.915	.945
8	.575	.693	.599	.743	.847	.884
16	.514	.684	.575	.726	.805	.879
32	.502	.599	.563	.685	.771	.816
64	.446	.596	.551	.682	.725	.814
128	.453	.530	.549	.646	.714	.755
256	.397	.530	.531	.645	.663	.755
512	.413	.478	.533	.611	.665	.703

Table A.3: Throughput at saturation of delta networks with switching elements of degree 4 for a searching algorithm.

Size	Single Plane		Two-Plane			
	Regular	Queue By-Pass	Regular	Queue By-Pass	Double Buffer	De-Luxe
8	.601	.771	.603	.775	.879	.931
16	.553	.652	.576	.719	.816	.861
32	.535	.649	.572	.712	.808	.857
64	.487	.647	.561	.710	.772	.857
128	.498	.560	.555	.667	.750	.786
256	.474	.559	.554	.665	.739	.786
512	.421	.558	.539	.664	.691	.786
1024	.452	.493	.543	.619	.694	.719
2048	.424	.493	.536	.619	.678	.719
4096	.371	–	–	–	–	–

Table A.4: Throughput at saturation of delta networks with switching elements of degree 8 for a searching algorithm.

Size	Single Plane		Two-Plane			
	Regular	Queue By-Pass	Regular	Queue By-Pass	Double Buffer	De-Luxe
16	.583	.752	.583	.754	.862	.921
32	.542	.635	.570	.704	.799	.845
64	.536	.632	.564	.698	.794	.843
128	.519	.632	.562	.700	.788	.843
256	.477	.630	.556	.697	.756	.842
512	.493	.544	.553	.653	.733	.769
1024	.485	.543	.553	.650	.734	.768
2048	.459	.542	.548	.649	.721	.767
4096	.409	.541	.533	–	.674	–

Table A.5: Throughput at saturation of delta networks with switching elements of degree 16 for a searching algorithm.

Delta Networks with a Flood-Planes Algorithm

Tables A.6 to A.9 give the throughput at saturation of two-plane delta networks constructed from switching elements of degree 2 to degree 16 with a flood-planes algorithm and a retry delay of 10% of the packet length. The results for the two-plane regular structure with a flood-planes algorithm are plotted in fig. 6.7. The flood-planes algorithm selects between multiple paths to the same destination by flooding across all planes in parallel but searching within a plane thus the results for a single plane structure are equivalent to the searching algorithm.

Size	Regular	Queue By-Pass	Double Buffer	De-Luxe
2	.742	.878	1.0	1.0
4	.648	.813	.930	.979
8	.599	.775	.850	.950
16	.576	.743	.786	.916
32	.560	.723	.733	.879
64	.543	.702	.688	.842
128	.529	.682	.650	.807
256	.514	.662	.618	.773
512	.499	.642	.589	.741

Table A.6: Throughput at saturation of delta networks with switching elements of degree 2 for a flood-planes algorithm.

Size	Regular	Queue By-Pass	Double Buffer	De-Luxe
4	.640	.808	.931	.981
8	.605	.767	.887	.947
16	.576	.752	.836	.942
32	.575	.725	.818	.895
64	.560	.724	.755	.892
128	.566	.697	.762	.842
256	.541	.696	.690	.840
512	.551	.668	.714	.791

Table A.7: Throughput at saturation of delta networks with switching elements of degree 4 for a flood-planes algorithm.

Size	Regular	Queue By-Pass	Double Buffer	De-Luxe
8	.601	.771	.897	.971
16	.581	.741	.861	.927
32	.575	.738	.848	.924
64	.566	.731	.799	.922
128	.568	.707	.806	.865
256	.563	.705	.783	.864
512	.548	.706	.718	.863
1024	.560	.674	.759	.804
2048	.553	.674	.726	.804
4096	.526	.674	.652	.801

Table A.8: Throughput at saturation of delta networks with switching elements of degree 8 for a flood-planes algorithm.

Size	Regular	Queue By-Pass	Double Buffer	De-Luxe
16	.583	.752	.883	.965
32	.577	.728	.849	.915
64	.573	.728	.842	.913
128	.573	.725	.829	.913
256	.562	.725	.786	.912
512	.566	.698	.797	.851
1024	.567	.695	.794	.847
2048	.563	.695	.769	.847
4096	.543	–	.703	.850

Table A.9: Throughput at saturation of delta networks with switching elements of degree 16 for a flood-planes algorithm.

Sub-Equipped Beneš Networks

Tables A.10 to A.13 present the throughput at saturation for the sub-equipped Beneš structure constructed from switching elements of degree 2 to 16. A retry delay of 10% of the packet length was used and results are given for both random and flooding algorithms with and without input queue by-pass. The results for the regular sub-equipped Beneš structure with a flooding algorithm are plotted in fig. 6.9(b).

Size	Regular		Queue By-Pass	
	Random	Flooding	Random	Flooding
2	.742	.742	.878	.878
4	.615	.634	.791	.804
8	.562	.579	.712	.741
16	.520	.548	.642	.697
32	.489	.532	.583	.662
64	.463	.521	.534	.636
128	.440	.514	.495	.614
256	.419	.508	.462	.598
512	.400	.503	.433	.584

Table A.10: Throughput at saturation of sub-equipped Beneš networks with switching elements of degree 2.

Size	Regular		Queue By-Pass	
	Random	Flooding	Random	Flooding
4	.640	.640	.808	.808
8	.582	.598	.734	.760
16	.551	.572	.686	.724
32	.524	.560	.629	.701
64	.510	.554	.596	.682
128	.485	.550	.551	.668
256	.473	.548	.529	.656
512	.450	.545	.494	.647

Table A.11: Throughput at saturation of sub-equipped Beneš networks with switching elements of degree 4.

Size	Regular		Queue By-Pass	
	Random	Flooding	Random	Flooding
8	.601	.601	.771	.771
16	.566	.582	.707	.747
32	.545	.572	.666	.728
64	.538	.567	.648	.715
128	.515	.567	.597	.708
256	.503	.565	.571	.698
512	.496	.565	.559	.693

Table A.12: Throughput at saturation of sub-equipped Beneš networks with switching elements of degree 8.

Size	Regular		Queue By-Pass	
	Random	Flooding	Random	Flooding
16	.583	.583	.752	.752
32	.557	.575	.695	.744
64	.544	.571	.657	.735
128	.538	.571	.640	.728
256	.535	.571	.632	.725
512	.513	.571	.584	.722

Table A.13: Throughput at saturation of sub-equipped Beneš networks with switching elements of degree 16.