

Variable Reordering on the QMDD Representation of Quantum Circuits

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ABSTRACT

In [1], a novel structure was discussed for representing the matrices that can be built from an n -variable r -valued reversible/quantum circuit. This structure, called a QMDD, takes on a form similar to that of a reduced-ordered-binary-decision-diagram (ROBDD). It is known that the order of variables used for developing an ROBDD from a binary logic circuit is relevant to the size and structure of that ROBDD [3]. This paper determines what effect, if any, variable order has on the QMDD structure and proposes a simple heuristic for choosing a ‘good’ variable order.

1. INTRODUCTION

Recent developments in the field of quantum mechanics have brought to light the possibility of the future existence of quantum computers. To this end, current computer scientists are beginning the theoretical research towards the use and benefit of quantum computers. This research requires tools for representation of quantum circuits and the ability to simulate quantum computation.

The work presented in [1] is a tool for representing quantum circuits on a classical computer. The software implements a model of a quantum circuit called a Quantum Multiple-Valued Decision Diagram (or QMDD). The existing software allows for creation of the model of a circuit and some analysis on the size and time complexity of that circuit.

In this work the implementation developed in [1] was extended to include a more robust set of quantum gates. Section 2 contains some background material on quantum circuits. A discussion of the existing implementation and the extension completed is included in Section 2. After completing the extension, an analysis of the effect of variable order on the QMDD structure was completed; this is discussed in Section 3. Following that, the paper discusses some results and future work in sections 4 and 5 respectively.

2. BACKGROUND

2.1. Quantum Circuits

Quantum circuits are similar to traditional logic circuits in that they are made up of wires and gates. However, quantum circuits are arranged in a much different fashion than traditional logic circuits. Figure 2.1 below shows an example of a traditional logic circuit (a) and an example of a quantum circuit (b). Quantum circuits can be developed to represent traditional logic functions (both binary and multi-valued functions). They are also capable of computing multiple traditional logic functions with one circuit.

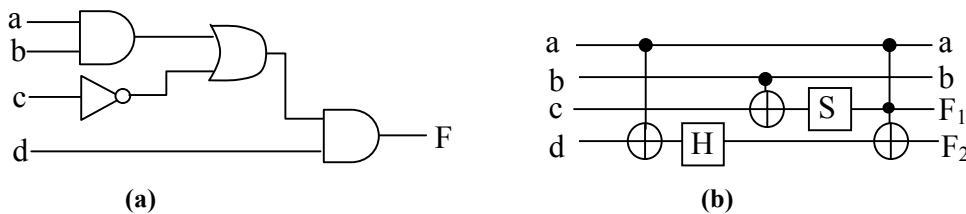


Figure 2.1

Each line in a quantum circuit represents a quantum bit, or qubit. Qubits are actual physical quantum mechanical objects that physicists are attempting to manipulate and control. Most of the discussion in this paper will be around using qubits as a mathematical representation of the physical objects.

Similar to traditional bits, qubits exist in states; traditional bits hold the states 0 or 1, whereas qubits can hold the states $|0\rangle$ and $|1\rangle$ (This notation is standard across the field of quantum mechanics). The difference with qubits is that they are able to exist in states other than $|0\rangle$ and $|1\rangle$, and with qubits you can form linear combinations of states called superpositions (Figure 2.2). Both α and β are complex numbers. [2]

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

Figure 2.2

Qubits are probabilistic objects as we cannot measure the actual state of a quantum bit. When a qubit is measured the value obtained is either a 0 or 1. When a measurement takes place the value of the qubit will be a 0 with probability $|\alpha|^2$ or a 1 with probability $|\beta|^2$, and since probabilities sum to one $|\alpha|^2 + |\beta|^2 = 1$. The states $|0\rangle$ and $|1\rangle$ form an orthonormal basis for a vector space which includes all vectors of the form $[\alpha \beta]$.

Each gate in a quantum circuit is a combination of a target and zero or more controls. The target is placed on the qubit line it needs to effect and the controls, if any, are placed on other qubit lines. A quantum gate with no controls is a single-qubit gate; single-qubit gates always affect the qubit line they are on (called target lines). Quantum gates with controls only affect the target line if all lines with controls (called control lines) are on (hold a value of 1). The word line and variable will be used interchangeably throughout this paper as variables are used to represent qubits in mathematical notation.

2.2. Matrix Representation

The application of a quantum gate to a qubit results in a transformation of the qubit. As these transformations are linear they can be represented as a linear combination of the $|0\rangle$ and $|1\rangle$ states. All single-qubit quantum gates can be represented as a two by two matrix that causes a linear transformation on the vector $[\alpha \beta]$. Quantum gates with controls are represented by a $2^b \times 2^b$ matrix where b is the sum of targets and controls for that gate. Each control line is represented by placing a two by two identity matrix on the diagonal in the $2^b \times 2^b$ matrix and the target is represented by its single-qubit matrix. (Figure 2.3)

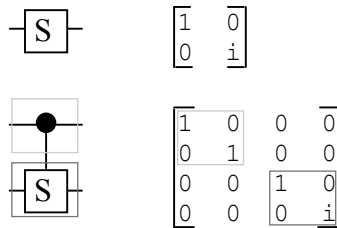


Figure 2.3

The one property that all of these matrices hold in common is they are unitary. For any matrix G that represents a quantum gate, it is unitary if $G^*G = I$ where I is the identity matrix and G^* is the adjoint of G . This is in fact the only constraint on what matrices represent quantum gates; and, since there are “infinitely many two by two unitary matrices, [there exists] infinitely many single-qubit gates” [2 p.19].

The matrix for a quantum gate in a circuit actually takes into consideration all lines of the circuit (the target line, the control lines and all non-control lines). To form a final transformation matrix which represents the entire quantum circuit, the individual gate matrices are multiplied together in the order that the gates are written in the circuit. The matrix for a quantum circuit is $2^n \times 2^n$ where n is the number of lines in the circuit.

2.3. QMDD Representation

The QMDD representation is described fully in [1]. The following is a brief overview of the work presented in that paper. Three vital functions are defined in the QMDD implementation: QMDD addition, QMDD multiplication and QMDD Kronecker product [4]. These three functions are defined based on the definitions of the corresponding matrix operations. These three functions are key to constructing a QMDD from a circuit definition.

The circuit to be represented is defined in a text file as follows: The first line of the file defines the number and label of each line (qubit) in the circuit. This line is followed by a 'begin' line. The next n lines define each of the n gates in the circuit. The gate type is listed first followed by a space and then a comma separated list of control lines. The last item in this comma separated list is the target line. The circuit definition is ended by the 'end' line.

The software reads in the circuit implementation one gate at a time. It proceeds to build the QMDD that would represent the gate if it was alone in the circuit. After building the individual gate it multiplies it by the existing QMDD definition using the multiplication function. This becomes the current QMDD definition. This process repeats until the entire file has been traversed.

In [1] the authors had implemented this tool to represent circuits containing only NOT, controlled-NOT, controlled-V and controlled-V⁺ gates. As part of the work for this paper the Hadamard, Pauli-Y, Pauli-Z, Phase and $\pi/8$ -Rotation gates were added to the implementation.

The authors also implemented some statistics tracking tools for testing the efficiency of their implementation. As described in [1], the authors took several measures to improve this efficiency as large circuits create large matrices and that means large amounts of space and time for manipulating them. Due to the creation of a separate QMDD for each gate and its subsequent manipulation into the larger QMDD, the authors felt it necessary to track how many nodes were created throughout the process. Also, they report the number of nodes in the final QMDD.

The authors felt they could save time by implementing a table to hold already computed values, as many computations are repeated in the creation of a QMDD. They track the number of times this table was accessed and how many times a 'hit' occurs (a 'hit' occurs when the value to be computed is in the table) for each type of calculation (addition, multiplication and Kronecker products).

The authors also implemented a timing tracker that read the clock time before and after the process ran. This was changed for this paper to read the processor's clock tick counter instead. This gives a more accurate value for how long the process takes. The implementation uses the rdtsc assembly instruction for x86 based architecture processors. This instruction is executed twice: once before the application runs and once after. The value in the TIME column is determined by subtracting the first value from the second.

3. VARIABLE REORDERING

The main goal of this research was to determine if the order of the lines in the quantum circuit mattered to the construction of the QMDD. When beginning this research the hypothesis I held originally was that this order would not matter as one can rearrange the lines in a quantum circuit and it does not affect the outcome of the circuit. That hypothesis, as was soon discovered, was incorrect.

Several circuits were defined and the QMDD's were constructed for every possible variable order. The statistics gathering tools in the implementation allowed tracking of the following values: final node count (FNC), total node count (TNC), compute table accesses (CTA), percent of addition hits/addition accesses (ADD), percent of multiplication hits/multiplication accesses (MULT), percent of Kronecker hits/Kronecker accesses (KRON), and clock ticks elapsed (TIME).

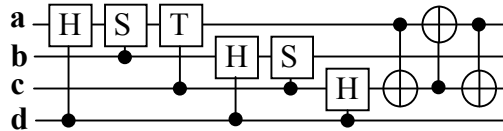
Statistics were obtained for each circuit three times. The only statistic that changes is the TIME. This statistic was recorded three times and averaged; the average value is tracked in the AVG column. As the TIME statistic is affected by how busy the processor is, outliers occurred in this data. An outlier is any data point that is greater than ten percent above or below the average. When an outlier was found the statistics for that order alone were obtained again.

The first circuit analyzed was a 3-bit Fourier Transform circuit. This is the only circuit in the group which has a defined functionality. The remaining circuits were built to test specific properties. A general discussion will follow each circuit diagram explaining the trends noticed. Then in section 4 there will be a discussion of the conclusions drawn from these trends.

All statistics attained from these tests are attached in appendix A. These statistics will be referenced frequently throughout this section of the paper. The main tables in appendix A are all sorted by the AVG statistic in ascending order as this appears to be the measurement most affected by the variable order. Other sub-tables are provided as well that are sorted differently. An explanation of the sort is described when the table is referenced in the paper.

A few definitions relating to the discussions of the circuits will now be explained. The **variable order** is a listing of the circuit line names (i.e. abcd is a variable order for a four line circuit). Two lines are **neighbors** if they are side-by-side in the variable order. A line being **early order** means the line name is listed before the midpoint of the order; conversely, being **late order** means it is listed after the midpoint of the order. The **upper region** of the data is the top values in the table when the data is sorted (when sorted by AVG this means those orders with the shortest average run times); conversely, the **lower region** is the bottom values in the table when the data is sorted. A gate that has a control on one line and a target on another line is considered **shared** by those two lines (every gate with at least one control is a **shared gate**). The **distance** between two gates is determined by the number of gates between them in the circuit.

3.1. Circuit 1

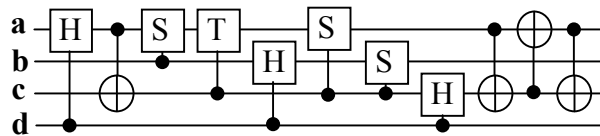


The data for circuit 1 is in table A.1.1. A noticeable trend that shows in the upper region of the data is that line **b** appears consistently early order. Another significant trend is that lines **a** and **c** are frequently neighbors in this region of data; however, lines **a** and **c** appear to be separated from each other in the lower region.

Conjecture: those lines with the greatest number of shared gates being neighbors in the variable order decrease the average running time.

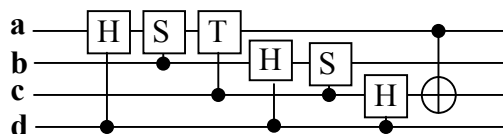
As lines **a** and **c** contain the most shared gates we would expect them to be neighbors in the upper region. To test this, statistics were run on a circuit containing more gates shared by lines **a** and **c**, as well as a circuit with less of these gates.

3.1.1. Circuit 1A



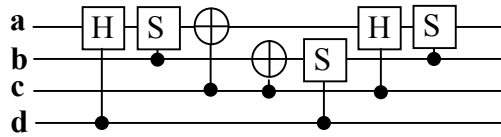
The data for this circuit is in table A.1.2. There does not appear to be any significant change in the data. The expected result here was that there would be a tighter coupling between lines **a** and **c** in the upper region. Not seeing a significant change may be due to lines **a** and **c** being as tightly coupled as possible in the first version of this circuit. As all orders with line **b** early order are at the top there cannot be any real change in the upper region.

3.1.2. Circuit 1B



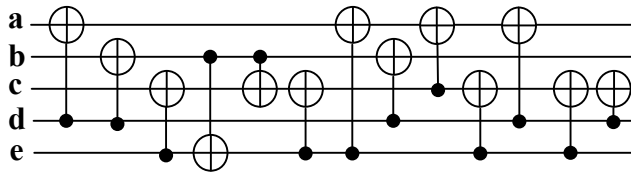
The data for this circuit is in table A.1.3. With this circuit it was expected to see less coupling between lines **a** and **c**. In the data for this circuit it is possible to see this uncoupling. In the upper region (where line **b** is consistently early order) orders with lines **a** and **c** separated appear closer to the top of the region than in circuit 1. Also, in the lower region we see orders where lines **a** and **c** are neighbors lower in this region than in circuit 1.

3.2. Circuit 2



The data for circuit 2 is in table A.2. The only noticeable trend in this data is that the line with the most controls on it (line **c**) is consistently early order in the last four rows of the lower region.

3.3. Circuit 3



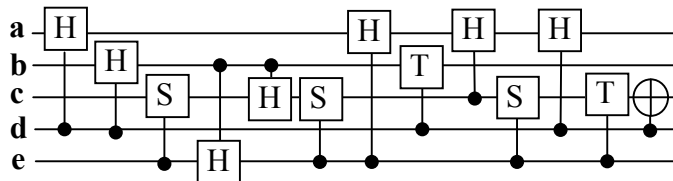
The data for circuit 3 is in table A.3.1. It was found that circuits with five qubits showed more noticeable trends as there was more data to investigate. When sorted by AVG the data showed a significant trend in the upper region: line **a** showed up most frequently early order. Line **a** is the line in the circuit with the fewest controls; it has zero.

Conjecture: lines with fewer controls early order cause a smaller average running time.

In the lower region for this data there is a trend towards lines **d** and **e** being early order. Lines **d** and **e** contain a significant number of the controls in this circuit.

Conjecture: lines with many controls, appearing early order, cause a larger average running time.

3.3.1. Circuit 3A

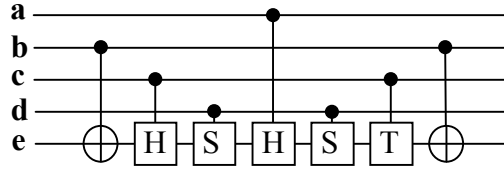


This circuit was tested to test whether the gates involved have a significant effect on the running time of the circuit. This is the exact same circuit as circuit 3, however, almost all of the CNOT gates have been changed to Hadamard, Phase and Rotation gates. To begin with, in order to run the test on this circuit the size of the table of computed values had to be increased from 256 entries to 1024 entries. Any smaller and the test would end prematurely for some orders and display an error message.

As can be seen in table A.3.2 the average running time (AVG) is much larger for this circuit. Also, the range of the AVG statistic is now about 33,000,000 whereas for circuit 3 it was about 1,400,000.

Other than this significant change, there seems to be no relevant new trend to the data. The same trends shown in circuit 3 seem to hold for this circuit.

3.4. Circuit 4



The data for circuit 4 is in table A.4.1. This circuit showed one significant trend in the upper region: lines **d** and **a** show up frequently early order. There also appeared to be two trends that showed in the lower region. In this region, line **b** is consistently early order and line **e** is frequently late order.

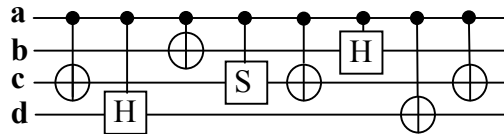
Conjecture: gates of greater distance that are connected to the same line will cause a longer average running time if placed early order.

Line **b** contains controls for the two gates in the circuit that are the furthest distance apart. Lines **d** and **a** are those that contain the fewest controls and contain gates that are closest together.

Conjecture: gates of shorter distance that are connected to the same line will cause a shorter average running time if placed early order.

Taking the data in the upper region that follow the trend mentioned above and sorting it by FNC resulted in most orders beginning with line **d** filtering to the top of the data. The data sorted in this fashion is in table A.4.2.

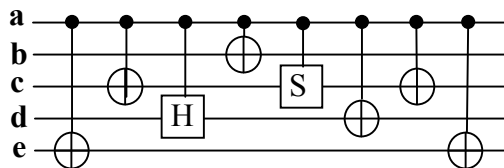
3.5. Circuit 5



Data for circuit 5 is in table A.5. This circuit was designed to test what effect control lines really have on the variable order. As can be seen in the data, line **a** plays a significant role. In the lower region, line **a** is consistently early order which reinforces the theory that lines with many controls appearing early order cause a larger TIME statistic. Line **a** also appears consistently late order in the upper region.

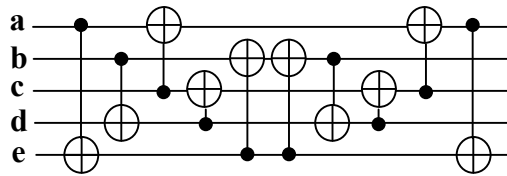
There also appears a trend in the upper region for lines **b** and **d** to be early order. The circuit shows no significant reason for this other than those lines having the least number of targets.

3.6. Circuit 6



Data for circuit 6 is in table A.6. This circuit shows similar trends to circuit 5. Line **a** is consistently early order in the lower region and consistently late order in the upper region. Those trends are more noticeable in this data as this circuit is five lines where as circuit 5 is four lines.

3.7. Circuit 7



The data for circuit 7 is in table A.7. The data in the table is sorted by AVG column. I sorted the data by each of the statistics recorded and then reviewed each sort for trends. There were no evident trends in any of the data for any of the sorts.

Conjecture: Circuits that have evenly distributed targets and controls on each line will be difficult to order effectively.

This circuit has evenly distributed targets and controls as there are two targets and two controls on each line. Also, with this circuit there appears to be evidence to refute the conjectures made about circuit 4 as there is no trend towards lines a or e causing a longer or shorter running time.

4. RESULTS

For every circuit analyzed, a significant difference was seen in the average running time between the best and worst variable order for that circuit. The worst AVG value was at least double the best AVG value in all cases. This shows that the variable order indeed has an effect on the running time of the software. Seeing as the only functionality the software performs at the moment is to build a QMDD of the circuit the aforementioned fact also shows that the variable order has an effect on the complexity of the QMDD.

The conjectures mentioned throughout this presentation can be utilized to develop an initial heuristic for determining a 'good' variable order given the circuit definition. I would begin by applying the conjectures from circuit 3 and then attempting to use the conjectures from circuit 1 to pair lines up. Seeing as these are only conjectures, they have yet to be fully tested. That is why I would be unsure how to handle the conflict seen about gate distance.

5. FUTURE WORK

This work is just a preliminary analysis as one would need a more complex and rigorous suite of test circuits to fully evaluate the QMDD structure. As far as I could tell there is no standard set of circuits that exist to test a representation structure this rigorously; some future work exists in finding one.

With a more rigorous analysis I am sure there are more trends that would be found. Also, the conjectures developed in this work need to be fully tested.

After finding more trends and fully testing the conjectures presented here, I am confident a sound heuristic could be developed to determine a 'good' variable order for the QMDD structure.

6. REFERENCES

- [1] D.M. Miller and M.A. Thornton, "QMDD: A Decision Diagram Structure for Reversible and Quantum Circuits", *ISMVL '06 Proceedings*, November 12, 2005.
- [2] M.A. Nielsen and I.L. Chuang, *Quantum Computation and Quantum Information*, Cambridge: Cambridge University Press, 2000.
- [3] Rudell, R. "Dynamic variable ordering for ordered binary decision diagrams". *International Conference on Computer-Aided Design Proceedings (ICCAD'93)*, 1993, pp. 42-47.

[4] E.W. Weisstein. "Matrix Direct Product." From MathWorld--A Wolfram Web Resource. <http://mathworld.wolfram.com/MatrixDirectProduct.html>, Mar. 3, 2006.

[5] http://www.quantiki.org/wiki/index.php/Main_Page, January 25, 2006

Appendix A: Data Tables

Table A.1.1

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
bcad	19	82	1018	62.1	31	44	1267561	1248912	1258906	1258460
bdac	21	91	1242	69.2	33.6	48	1353131	1342553	1335615	1343766
bdca	21	91	1229	68.1	37	47.2	1323426	1328995	1409681	1354034
bacd	18	84	1111	66.4	33.5	46.8	1459184	1297965	1450507	1402552
badc	20	106	1373	69.8	38.6	50.9	1422214	1424873	1421776	1422954
bcda	21	104	1267	66.6	39.7	45.8	1463233	1376090	1457355	1432226
dbca	19	94	1920	69.9	38.9	57.1	1735191	1896716	1811257	1814388
dbac	19	94	1901	70	34.3	56.6	1751051	1752219	1998489	1833920
cabd	30	128	1965	57.2	15.8	39.6	2251302	2264090	2260853	2258748
cbad	32	124	1984	56.1	15.5	41.1	2279001	2252641	2249521	2260388
acbd	17	105	2282	63.7	23.7	32	2241527	2411457	2245249	2299411
cadb	32	142	2160	59.9	20.6	37.5	2309133	2331063	2316889	2319028
abcd	19	104	2400	65.8	24	39.3	2306819	2322566	2460827	2363404
acdb	19	119	2465	65.8	26.3	37.7	2331541	2346960	2506965	2395155
cbda	34	146	2249	59.6	21.8	41.5	2435647	2397157	2549208	2460671
dcab	27	138	2771	67.7	37.8	50.9	2515167	2479605	2476602	2490458
dcba	27	146	2838	66.5	39.1	53.2	2522289	2537066	2521755	2527037
abdc	21	126	2678	66.8	27	40.3	2639380	2634194	2465128	2579567
dacb	22	138	3016	69.2	31.5	51.8	2783524	2722007	2723543	2743025
cdab	42	177	3065	67.4	35.7	40	2788241	2959219	2791061	2846174
dabc	22	146	3070	67.3	29.5	58.1	2993816	2807996	2811655	2871156
cdba	42	185	3164	66.2	36.1	38.2	2937509	2844979	2853652	2878713
adcb	27	155	3615	72	39.5	42.4	2914569	3030421	2918751	2954580
adbc	25	161	3633	70.6	38	47.7	2961489	3120928	2957178	3013198

Table A.1.2

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
bcad	19	93	1206	60.9	31.4	36.7	1460621	1439316	1443121	1447686
bacd	18	94	1495	70.3	37	43.9	1520646	1511838	1505167	1512550
bdca	21	99	1335	68.3	39.1	52.5	1670787	1471007	1561739	1567844
bdac	21	98	1508	70.2	37.5	50	1771438	1507705	1517736	1598960
bcda	21	115	1474	66	40.4	48.6	1626699	1607497	1607169	1613788
badc	20	116	1904	73.3	42.8	53	1846714	1765178	1749890	1787261
dbca	19	102	2154	69.9	39.7	59.4	2009586	1990754	1992256	1997532
dbac	19	101	2183	71.2	37.9	60.7	1980252	2051756	2124712	2052240
cbad	32	137	2385	57.6	18.3	43.7	2796265	2623153	2617403	2678940

cabd	30	146	2427	59.4	18.4	41.5	2675697	2727027	2635247	2679324
cbda	34	159	2653	60.6	24	45.8	2722236	2700429	2710308	2710991
acdb	19	141	2979	67.8	26.6	40	2813569	2793160	2786665	2797798
cadb	32	161	2606	61.3	23	38.2	2817344	2717794	2873609	2802916
acbd	17	126	2772	65.9	22.5	40.3	2858837	2843353	2751371	2817854
dcab	27	163	3135	67.6	38.7	55.1	3135154	2921537	2929848	2995513
dcba	27	170	3237	67.5	39.5	58.7	3021822	3153839	3035862	3070508
abcd	19	119	3061	67.1	25.3	46.5	2978656	3104422	3155692	3079590
dacb	22	145	3484	72.3	36.1	56.1	3095607	3064997	3123983	3094862
cdab	42	193	3514	67.4	36	43.8	3190813	3192200	3206187	3196400
abdc	21	144	3466	69.4	28	46.3	3219556	3357495	3224224	3267092
dabc	22	152	3653	70.7	36.2	54.7	3386421	3203392	3220342	3270052
cdba	42	200	3584	67	35.9	46.5	3314115	3307453	3216021	3279196
adcb	26	170	4380	75.1	37.7	48.7	3773965	3739000	3816853	3776606
adbc	25	177	4573	72.8	37.1	51.8	4064904	4033721	3960115	4019580

Table A.1.3

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
bcad	15	57	654	57.2	29	32.5	1000966	1062779	1003106	1022284
cbda	17	68	804	63.3	37.7	34.8	1083240	1095031	1101951	1093407
bacd	17	64	699	60.4	25.8	35.1	1090700	1156694	1059568	1102321
badc	19	79	846	65.1	31.3	37.5	1120889	1119416	1133804	1124703
bdca	21	72	1011	68.8	41.2	40	1139391	1140041	1150059	1143164
bdac	21	76	1024	69.4	36	38.1	1254566	1248335	1188534	1230478
cbad	16	63	927	52.3	16.8	31.7	1274777	1273582	1273981	1274113
cabd	18	71	959	54	18.2	31.7	1294707	1358469	1298221	1317132
cbda	18	74	1077	57.8	25.1	36.2	1324583	1336954	1326568	1329368
cadb	20	81	1090	58.1	23.4	29.6	1413956	1364547	1361757	1380087
abcd	16	71	1143	61	20.1	31.7	1425147	1412765	1427120	1421677
acdb	18	82	1263	63	28	29.3	1457482	1473215	1463180	1464626
abdc	18	86	1290	63.3	24.4	34.1	1503672	1496995	1506137	1502268
acbd	16	72	1132	60.4	23.2	29	1411393	1468608	1628606	1502869
cdba	22	88	1576	65.9	39	36	1557133	1570729	1561049	1562970
dbac	19	79	1683	70.2	35.9	48.9	1591280	1577925	1583083	1584096
cdab	22	87	1560	66.4	36.5	36	1727249	1551388	1552448	1610362
dbca	19	75	1702	70.5	41.6	50	1712504	1551852	1629942	1631433
dcba	19	85	1975	69.1	45.7	44.9	1752503	1736207	1826151	1771620
adcb	24	100	1922	71.2	39.9	36.4	1780794	1801713	1807913	1796807
dcab	19	84	1991	69.5	42.9	42.9	1782021	1775661	2006902	1854861
adbc	24	105	1933	69	37.4	38.3	1879080	1883889	1830538	1864502
dacb	23	98	2196	70.3	34.2	45.7	2019443	2039556	2048956	2035985
dabc	23	103	2199	68.4	31.9	49	2188358	2048360	2050831	2095850

Table A.2

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
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dabc	20	60	525	60.9	33.9	41	893889	892454	897217	894520.0
adbc	16	60	605	60.7	32.2	30.8	988815	942264	922492	951190.3
dacb	22	66	640	64.4	36.4	40.5	939042	1002972	987112	976375.3
abdc	16	64	670	61.9	34	37.5	965935	1025317	951063	980771.7
adcb	18	66	720	64	33.9	31	986872	992493	986698	988687.7
badc	18	60	733	61.7	30.1	38.5	993285	995845	1000422	996517.3
bacd	18	62	749	61.7	32.6	43.6	1015535	1003491	1004470	1007832.0
dbac	24	72	684	64	41.7	42.1	990123	1080748	987443	1019438.0
abcd	16	66	702	62.2	34.4	37.5	1154507	995941	973995	1041481.0
acbd	20	73	877	65.9	39.8	33.3	1080864	1069061	1066839	1072254.7
bdac	22	68	817	66	36.6	39.5	1040031	1191420	1030946	1087465.7
acdb	22	77	960	67.8	41.8	35.7	1099036	1100274	1099353	1099554.3
bdca	24	100	1194	70	40.2	42.3	1208599	1213148	1210350	1210699.0
dbca	26	104	1045	69	47.4	40.4	1174031	1166592	1406205	1248942.7
bcad	22	80	1210	68.9	42.7	38.6	1221859	1389868	1213019	1274915.3
cabd	14	67	1438	74.2	42	37.5	1316760	1311648	1320685	1316364.3
dcab	30	85	1541	76.8	52.4	40.4	1357113	1349323	1344594	1350343.3
cadb	16	71	1537	74.1	42.5	39.5	1355565	1353830	1356218	1355204.3
bcda	24	110	1526	70.6	46.3	35.7	1567973	1387995	1392264	1449410.7
dcba	30	111	1784	74.5	51.1	40	1497899	1485027	1487407	1490111.0
cbad	14	78	1721	69.2	38.2	39.5	1501189	1494001	1507277	1500822.3
cdab	20	79	2185	78.1	49.1	47.1	1654977	1651005	1650863	1652281.7
cbda	16	108	2085	72.1	43.9	40	1678253	1660696	1669728	1669559.0
cdba	20	105	2476	76.5	47.9	40.7	1828149	1818347	1847495	1831330.3

Table A.3.1

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
acebd	14	87	1209	76.8	53.9	59.7	1131515	1109737	1126811	1122687.7
caebd	16	91	1260	75.2	49.3	65	1165015	1152930	1163997	1160647.3
acedb	14	96	1441	78.1	54.8	64.9	1240084	1261551	1221710	1241115.0
acbed	18	89	1547	79	55.1	65.8	1269431	1247748	1258919	1258699.3
acdeb	14	89	1608	79.7	54.6	66.7	1299800	1288695	1285722	1291405.7
cabed	20	93	1630	78.7	51	67.1	1323625	1306803	1303543	1311323.7
acdbe	16	92	1690	79.8	54.8	62.8	1319741	1317856	1298121	1311906.0
abced	18	93	1724	79.2	54.8	66.3	1342327	1320815	1338574	1333905.3
cadbe	18	96	1645	80	53.1	63	1404879	1293426	1317490	1338598.3
acbde	20	101	1790	80.5	55.9	65.9	1363690	1336599	1336290	1345526.3
caedb	16	100	1524	77.4	52.2	66.3	1437946	1342836	1272032	1350938.0
adbce	20	101	1786	81.1	57.7	61.5	1367466	1371603	1347540	1362203.0
adcbe	16	91	1853	82.4	55.8	50.6	1371819	1362433	1352956	1362402.7
cadeb	16	93	1723	79.5	52.8	59.8	1415315	1345696	1328756	1363255.7
cabde	22	105	1825	79.3	52.9	67.1	1372807	1366007	1361609	1366807.7
adceb	14	88	1787	80.9	55.6	55.2	1362486	1365196	1408824	1378835.3
abdce	20	106	1726	80.4	55.8	65.9	1334989	1476266	1407676	1406310.3
ceabd	20	115	1762	75	54.3	62.2	1391445	1455683	1371962	1406363.3
baced	18	97	1954	79.9	53.6	59.3	1448421	1434526	1428987	1437311.3
cbead	20	120	1874	75.9	52.8	60.5	1490505	1443489	1420248	1451414.0

adbec	20	104	1933	81.7	53.8	63	1442093	1506907	1432755	1460585.0
daceb	14	89	2021	80.5	53.5	63.9	1560273	1439876	1433981	1478043.3
abdec	20	109	1777	80.3	52.8	65.9	1621910	1380320	1448498	1483576.0
dacbe	16	92	2167	81.9	53.4	62.6	1493922	1490332	1475963	1486739.0
abcde	20	105	1935	80.1	56.1	65.1	1582854	1487876	1398566	1489765.3
bacde	20	109	2149	80.2	55.3	67.4	1471412	1514867	1510272	1498850.3
bcead	18	120	2015	76.1	52.7	60.2	1495815	1541182	1474876	1503957.7
bcaed	22	108	2113	77.7	53	64.7	1520694	1510233	1507221	1512716.0
badec	20	113	2055	80.7	51.5	63.7	1515442	1519135	1503890	1512822.3
ceadb	20	124	1990	77	56.8	65.9	1472833	1451440	1614518	1512930.3
badce	20	110	1972	80.7	53.9	60.2	1469738	1483969	1591045	1514917.3
dabce	20	102	2212	81.4	55.5	65.9	1530472	1511875	1508463	1516936.7
cbeda	20	141	2056	75.2	53.3	52.2	1533525	1517873	1522389	1524595.7
abecd	14	105	2027	80.3	53.9	63.3	1485690	1466183	1625607	1525826.7
becad	14	125	2014	77.7	54.5	63.4	1577265	1510749	1493311	1527108.3
bdace	20	113	2114	79.1	55.4	65.6	1547550	1523261	1518782	1529864.3
ebcad	16	125	2060	77.3	55.5	68.8	1541331	1524319	1531316	1532322.0
cebad	20	129	1812	74.7	54.5	53.4	1613445	1574527	1434707	1540893.0
aecbd	14	95	2040	81.9	59.1	61.8	1646819	1447878	1545226	1546641.0
ecabd	20	115	2189	77.8	55.7	60.5	1557033	1552576	1539573	1549727.3
cbade	26	120	2215	78.8	53.3	64.8	1562411	1544574	1542270	1549751.7
dbace	20	110	2262	81	57.2	63.8	1570816	1555027	1565085	1563642.7
cebda	20	150	2058	73.5	54.5	61.7	1558237	1538853	1643109	1580066.3
baecd	14	109	2193	79.5	51.6	63.5	1563206	1550912	1644167	1586095.0
dbaec	20	113	2149	80.2	54.1	60.8	1699525	1528052	1536725	1588100.7
ecbad	20	129	2099	75.8	55.6	58.6	1582944	1542438	1642153	1589178.3
dabec	20	105	2359	81.9	52.6	65.9	1591438	1589515	1591466	1590806.3
bceda	18	141	2165	75.2	53.8	64	1589139	1601093	1587082	1592438.0
cdabe	18	105	2407	82.2	56.7	62.6	1655248	1579966	1592597	1609270.3
bcade	24	120	2404	79.4	54.2	65.9	1629853	1618098	1611173	1619708.0
becda	14	146	2340	77.5	56.1	63.6	1635223	1616678	1622382	1624761.0
aecdb	14	104	2272	82.5	60.4	63.2	1556595	1697310	1624348	1626084.3
cdaeb	16	102	2389	82.3	58.1	58.8	1750935	1584881	1581904	1639240.0
bdaec	20	116	2149	79.9	53.4	64.5	1589290	1794060	1558387	1647245.7
eacbd	16	99	2374	80.3	54.4	63.3	1629738	1701697	1611757	1647730.7
dcaeb	14	99	2524	81.3	58.7	62.5	1638826	1619968	1689662	1649485.3
cbaed	24	108	2052	77.7	50.4	64.8	1867395	1625511	1471109	1654671.7
abedc	16	120	2266	79.1	51.4	61.7	1602766	1747936	1660189	1670297.0
beacd	14	125	2427	78	53.9	68.4	1731185	1661172	1664975	1685777.3
ebcda	16	146	2466	77.1	57.1	59.8	1729950	1712472	1710393	1717605.0
ecbda	20	150	2441	76.1	56.1	58.1	1703145	1771361	1685750	1720085.3
baedc	16	124	2496	79.9	51.7	66	1768869	1683186	1749327	1733794.0
dcabe	16	102	2670	83.4	59.7	69.4	1668567	1900608	1651706	1740293.7
adebc	20	127	2679	81.6	53	55.6	1755105	1758674	1744122	1752633.7
aebcd	14	109	2541	82.7	58.6	65.2	1746695	1869508	1669849	1762017.3
ecadb	20	124	2329	77.5	56.4	61.7	1637616	1959910	1770843	1789456.3
aebdc	16	124	2836	82.1	57.4	70.2	1819895	1792847	1820657	1811133.0
beadc	16	140	2810	79.9	53.4	67.3	1830559	1812408	1813076	1818681.0

adecb	18	121	2806	82.6	55.8	54.4	1866388	1842282	1759919	1822863.0
ebacd	16	125	2681	80.2	54.9	72.5	1878424	1785045	1820650	1828039.7
bdcae	16	144	2809	78.3	57.2	66.7	1842416	1809377	1850648	1834147.0
cbdae	22	152	2825	78.4	56.6	60.2	1836464	1803672	1869392	1836509.3
eacdb	16	108	2718	81.6	56.4	63.3	1851989	1915355	1750610	1839318.0
dbeac	16	124	2803	80.1	53.7	72.2	1915996	1807875	1804070	1842647.0
cbdea	20	161	2863	76.8	55.8	65.7	1860100	1853448	1833066	1848871.3
daebc	20	128	2977	79.7	49.7	67	1858761	1843765	1853158	1851894.7
bedac	16	140	2840	80.1	56	68.1	1839604	1829306	1916165	1861691.7
dbcae	16	141	2925	78.5	58	67	1876384	1862941	1864121	1867815.3
bdcea	14	153	2847	76.7	56.1	62.6	1872567	1867309	1864700	1868192.0
cdbae	18	146	3085	80.7	58.3	62.9	1905959	1885988	1885232	1892393.0
bdeac	16	127	2775	78.9	52.6	71.2	2078000	1818030	1819637	1905222.3
dbeqa	14	130	2918	80	57.9	71.7	1863837	1921451	1939101	1908129.7
cedba	20	177	2690	76.8	58	66.7	1894030	2046496	1784971	1908499.0
bdeca	14	133	2818	80.4	55.8	67.7	1833281	2071530	1820775	1908528.7
eabcd	16	113	3107	81.8	55.6	62.1	1929987	1913803	1910010	1917933.3
dbcea	14	150	2979	77.1	55.4	68	1909850	1897315	1964446	1923870.3
bcdae	20	152	2890	78	56.8	60	1941107	1841663	2000121	1927630.3
ebadc	18	140	3064	81.1	54.3	70.2	1936384	1919101	1939908	1931797.7
cdeba	16	162	3069	79.1	58.4	68.1	1910377	1911225	1978997	1933533.0
bedca	14	146	2903	80	57.6	69.2	2069591	1884101	1881349	1945013.7
cedab	20	165	2756	78.2	56.7	65.6	2032490	1796698	2036025	1955071.0
cdeab	16	150	3231	80.4	57.9	67.3	1962692	1959041	1947044	1956259.0
daecb	18	122	3104	81.5	52.6	64	1893918	1895407	2086809	1958711.3
ebdac	18	140	3078	80.5	57.2	71.5	1967982	1942439	1988149	1966190.0
dceab	14	147	3286	81.3	58.4	68.4	1980543	1965872	1969873	1972096.0
ecdba	20	177	3025	77.6	57.7	61.4	2057400	1945122	1929323	1977281.7
cdbea	16	155	3187	79.4	58.4	66	2044524	1950357	1948257	1981046.0
aedcb	18	130	3351	83.7	60.1	65.3	1978143	1985115	1989543	1984267.0
dceba	14	159	3236	80.1	58.7	70.8	1974938	2035158	1977681	1995925.7
aedbc	20	136	3260	83.1	58.1	68.3	1974039	2050760	1983357	2002718.7
bcdea	18	161	3084	77.3	56.7	64.6	2175548	1940234	1940520	2018767.3
eabdc	18	128	3234	81.6	55.3	72	1985354	1971380	2125880	2027538.0
dcbea	14	152	3322	79.9	58	68.2	2014453	2012898	2071199	2032850.0
ebdca	16	146	3381	80.1	59	66.9	2076984	2060260	2064067	2067103.7
ecdab	20	165	3127	79.4	57.4	57.9	1972385	2117356	2124756	2071499.0
eadbc	22	140	3626	82.1	55.6	67	2141932	2124128	2145496	2137185.3
dcbae	16	143	3236	81.6	58.8	67.3	2115121	2258336	2098281	2157246.0
eadcb	20	134	3801	82.9	57.1	63.3	2185447	2192065	2241758	2206423.3
debca	18	139	3820	81.7	60.1	76.6	2267430	2195835	2219589	2227618.0
edbca	20	142	3821	82	61.2	69.8	2256414	2239249	2236920	2244194.3
debac	20	133	3965	83.1	57.8	75.9	2262644	2256094	2248187	2255641.7
deabc	24	145	4083	82.8	57.1	74.1	2350309	2289516	2277510	2305778.3
decab	18	154	4249	83.7	59.9	70.9	2372317	2338617	2340509	2350481.0
deacb	22	139	4046	82.8	59	72.1	2289925	2437485	2362166	2363192.0
edabc	26	148	4264	82.9	57.7	71.2	2384257	2365335	2372788	2374126.7
edcab	20	157	4250	83.1	59.8	71.2	2391352	2367709	2371215	2376758.7

decba	18	166	4255	82.7	60.9	73.2	2439968	2382941	2468971	2430626.7
edacb	24	142	4427	83.4	59.1	70.7	2446466	2425708	2423429	2431867.7
edbac	22	136	4090	83.1	59	73.2	2423070	2485253	2477467	2461930.0
edcba	20	169	4280	82.2	61.1	65.3	2479004	2639438	2566327	2561589.7

Table A.3.2

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
abecd	23	141	2667	59.4	30.9	45.6	2777949	2774496	2769783	2774076.0
aecbd	20	139	2568	53.1	28.7	46.1	2789778	2978750	2804882	2857803.3
abcd	23	147	2828	60.4	32.5	51.3	2883966	2895375	3051215	2943518.7
aebcd	24	157	2677	56.5	30.2	47.2	2990194	2888859	3008605	2962552.7
aebdc	26	181	2980	59	32.8	53.9	3005230	3031494	3019715	3018813.0
abcde	25	164	3071	62.3	36.3	48.2	3021986	3035821	3011628	3023145.0
acebd	22	144	2761	52.8	28.3	46.8	3021234	3051592	3025879	3032901.7
abedc	25	165	3018	62.2	34	50	3092169	3230094	3015064	3112442.3
aecdb	22	161	2952	55.3	32.4	46.1	3198703	3088200	3111925	3132942.7
baced	26	159	3442	61.2	34	50	3143425	3162713	3135034	3147057.3
baecd	26	153	3329	60.8	32.6	48.2	3165050	3075470	3251723	3164081.0
abdce	33	157	3374	65.2	39.4	54.9	3200967	3198848	3111333	3170382.7
baedc	28	177	3632	63.4	34.9	50	3233925	3293417	3400568	3309303.3
acbed	26	170	3067	55.1	29.2	50.6	3289590	3279429	3445794	3338271.0
acedb	24	166	3161	55.9	32.1	42.9	3227681	3386535	3427765	3347327.0
bacde	28	176	3685	62.7	36.4	52.8	3379187	3292543	3464616	3378782.0
abdec	33	165	3553	64.9	37.7	54.1	3551151	3318233	3321771	3397051.7
acbde	28	187	3214	58.4	33.1	45.1	3290757	3383297	3532126	3402060.0
badce	36	167	4052	65.5	39.4	45.5	3453865	3484237	3454777	3464293.0
aedcb	30	209	3819	62.7	38.8	45.3	3526941	3600776	3510254	3545990.3
badec	36	175	4055	64.4	38.2	48.4	3703746	3522046	3525792	3583861.3
acdeb	32	217	3776	61.3	38.6	39.3	3706870	3556821	3567464	3610385.0
aedbc	32	219	3860	60.2	35.7	45.2	4373916	4217899	4215957	4269257.3
beadc	46	271	4314	59.9	29.6	40	4362588	4361817	4374307	4366237.3
acdbe	34	222	3818	59.1	35.5	42.3	4446008	4402701	4293259	4380656.0
beacd	44	247	4011	58.3	28.5	44.2	4220913	4472555	4517264	4403577.3
adceb	32	197	4555	64	40.8	39.1	4409421	4410131	4401555	4407035.7
bcaed	44	253	4241	59.4	30.7	45.9	4578658	4490189	4574132	4547659.7
adecb	32	203	4734	64.2	40.2	40	4680612	4655498	4654127	4663412.3
bcade	46	270	4468	60.2	32.4	42.1	4667517	4843597	4931472	4814195.3
bdace	56	223	6110	69.7	44.6	48.9	5089924	4969920	5086984	5048942.7
bdaec	60	235	6145	69.2	44.3	50.5	5078220	5081801	5080292	5080104.3
becad	45	277	4270	55.9	25.1	43.9	5179441	4989608	5226045	5131698.0
bcead	45	276	4479	57.3	27.6	43.4	5154365	5129452	5284823	5189546.7
eabcd	48	215	4563	55.6	22.9	39.8	5403837	5234281	5231445	5289854.3
eacbd	44	197	4374	53.5	22.5	42.2	5432839	5275395	5266193	5324809.0
adcbe	40	199	5005	65.5	41.1	40.7	5489653	5493844	5579206	5520901.0
eaedb	46	219	4790	55.9	25.8	33.3	5736509	5465938	5394665	5532370.7
eabdc	50	239	4834	57.2	25.6	49.2	5672795	5408188	5662565	5581182.7
adbec	43	187	4781	65.9	40.6	50.6	5708331	5733167	5718257	5719918.3

adbce	44	184	4906	66.8	41.9	47.4	5803206	5799561	5709418	5770728.3
ebacd	62	277	5177	58	26	43.1	5877014	5833176	5720797	5810329.0
eadcb	54	267	5657	60.1	31.8	44	6034153	5864964	5867503	5922206.7
becda	48	330	4916	57	27.7	38.6	6021656	5866020	5999884	5962520.0
bcdae	53	389	6070	64.6	39.2	34.4	5870730	6115541	5921159	5969143.3
ebadc	64	301	5448	59.4	27.8	45.2	6148815	5973641	5966385	6029613.7
caebd	56	229	4980	54.8	21.3	37.5	6297266	6139822	5961215	6132767.7
caedb	58	251	5324	56.2	24.4	35	6102539	6271135	6083425	6152366.3
cabed	60	255	5150	56.3	23.1	39	6193526	6263006	6103514	6186682.0
adebc	32	207	5335	64	39.2	44.4	6226029	6268232	6174339	6222866.7
bedac	56	437	6288	63.5	36.6	41.4	6295803	6161513	6319019	6258778.3
cabde	62	272	5377	57.1	25	36.5	6330294	6529116	6260480	6373296.7
ecabd	51	258	5325	54.5	20.6	33.3	6477847	6342982	6308429	6376419.3
bceda	49	336	5221	58	29.2	43.8	6323613	6404660	6466426	6398233.0
ecadb	53	280	5661	57.3	24	33.3	6625297	6421006	6509061	6518454.7
bedca	56	459	6551	63	36.4	44.9	6649407	6485831	6560949	6565395.7
ecbad	54	294	5575	53.9	20.7	31	6511298	6611252	6697896	6606815.3
cbaed	72	314	5732	59.2	25.7	34.1	6766668	6741504	6536323	6681498.3
cadeb	66	302	6035	59.1	28.8	34.5	6728665	6736506	6655456	6706875.7
ecbda	56	341	6137	56.4	24.1	32.3	6773201	6855915	6926104	6851740.0
cbade	74	331	5975	59.8	27.3	35.2	7015369	6934043	6897117	6948843.0
eadbc	65	297	5698	60	30.1	44.1	7212136	7243003	7119105	7191414.7
ceadb	61	309	6190	56.7	23.8	34.2	7419486	7424815	7249212	7364504.3
bdcae	59	365	8029	68.9	43.3	37.6	7488685	7299775	7401444	7396634.7
bcdea	53	438	6764	61.7	34.1	43.8	7345894	7348591	7500464	7398316.3
ceabd	59	287	5790	54.3	20.5	34.2	7577528	7445580	7398134	7473747.3
cebad	62	323	6068	54.4	20.7	31.8	7610107	7619694	7435217	7555006.0
ecdab	63	406	7675	62.6	33.9	30.5	7674186	7615075	7943826	7744362.3
cebda	64	370	6698	56.3	24	34	7850073	7935582	7662056	7815903.7
ebdac	78	477	7382	62.7	34.2	36.9	8284073	7939504	8028221	8083932.7
ebcad	73	354	5628	55.8	22.1	37.5	8352738	8089818	8165822	8202792.7
cbdae	82	456	7545	62.6	32.8	32.3	8333444	8172943	8382199	8296195.3
ebcda	75	404	6242	57.7	25.6	33.3	8329490	8334640	8472176	8378768.7
cbead	77	357	6114	57.4	23.3	34.9	8284001	8429761	8445249	8386337.0
cedab	71	435	8324	62.4	33.5	32.3	8826327	8666428	8759692	8750815.7
cadbe	77	343	6093	58.3	27.6	35.8	8893815	8926643	9016402	8945620.0
cdaeb	93	496	9637	67	40.7	29.9	9031538	9327163	9280263	9212988.0
ecdab	79	494	8161	61.3	34.4	31.7	9315680	9294472	9336099	9315417.0
bdeac	74	427	8603	66.5	40.3	42.3	9349843	9451558	9412389	9404596.7
bdcea	59	427	9095	66.8	40.7	36.4	9327357	9441771	9591977	9453701.7
edacb	91	495	10515	69.2	43.2	39	9736762	9595300	9825478	9719180.0
daecb	42	251	9072	70.5	37.3	39	9914813	9969836	9808844	9897831.0
daceb	42	245	9413	71.5	38	37.1	10083254	9893537	10103695	10026828.7
ebdca	82	544	7973	60.9	32.5	40.5	10173509	10178754	10164558	10172273.7
cbeda	82	444	7224	58.1	24.4	33.7	10596431	10560073	10465917	10540807.0
edcab	92	578	11602	67.6	42.8	37.3	10626777	10436813	10588613	10550734.3
bdeca	76	471	9330	66.2	38.8	41.2	10891939	10947172	10851912	10897007.7
edabc	97	510	10464	68.6	42.4	39.4	11624407	11524441	11447833	11532227.0

cbdea	85	546	8687	60.3	30.6	33.3	11784246	11463109	11697070	11648141.7
cedba	87	551	8994	60	30.4	33.3	11787495	11689080	11650823	11709132.7
cdabe	103	539	9927	66.4	39.9	36.3	11940987	11826919	11972494	11913466.7
dcaeb	69	463	11816	69.6	39.2	38.5	12340425	12169849	12080220	12196831.3
cdeab	103	625	11339	65	39.6	34.6	12556948	12667261	12579641	12601283.3
edcba	113	684	12364	65.9	41.6	37.9	13180914	12993363	12918227	13030834.7
dacbe	60	280	10163	70.9	37.2	36.3	14049897	14069845	14168290	14096010.7
dabce	74	280	10020	72.1	39.1	45.5	15044826	15226038	15049737	15106867.0
daebc	52	285	10813	70.6	36.2	40.4	15308609	15269495	15288728	15288944.0
cdbae	114	693	11133	66	39.4	34	15288492	15293638	15321043	15301057.7
dabec	79	289	10159	71.9	37.8	46.2	15394920	15356065	15423160	15391381.7
dceab	75	566	13462	68.5	38.3	36.8	15629902	15813172	15687474	15710182.7
deacb	77	506	13410	69.5	36.8	41.8	15724469	15753632	15712275	15730125.3
edbac	113	717	12102	68	42	41.3	16327338	16371427	16356865	16351876.7
decab	75	582	14105	68	37.4	38.5	17059489	17009218	16998716	17022474.3
dcabe	82	479	13102	69.9	37.5	38.8	17004551	17245046	16984904	17078167.0
cdeba	118	756	12617	63.6	37.9	33.6	17942017	17936527	17932503	17937015.7
dbaec	129	427	12869	72.3	39.3	49.5	19590587	19692166	19499316	19594023.0
dbace	103	420	13318	73.1	39.7	43.6	20689174	20610385	20706494	20668684.3
dcbae	90	623	14668	69.5	39	39.4	21449851	21251094	21446590	21382511.7
deabc	89	534	14727	69.6	35.6	45	21813663	22077121	21832248	21907677.3
dceba	78	643	15472	67.2	36.4	40.8	22082119	22164027	22160293	22135479.7
edbca	121	801	12813	66.9	40.9	36.4	22410249	22247341	22075023	22244204.3
cdbea	124	837	12691	64.1	37.5	33	23293679	23274060	23283522	23283753.7
decba	78	659	16159	68	36.1	39	23587537	23490784	23529733	23536018.0
dbcae	101	540	15353	72.2	40	41.2	26900062	26816864	27138210	26951712.0
dbeac	121	590	15795	71.1	38.7	45.2	28095670	28069306	28030304	28065093.3
debac	94	708	16697	69.4	35.9	40.9	29908127	29988512	29734768	29877135.7
dcbea	96	726	17242	68.2	35.9	40	32542108	32257092	32466088	32421762.7
dbcea	103	625	16535	69.8	38.3	39.8	33826268	33899794	34060851	33928971.0
dbeca	119	631	16990	70.9	37.9	41.5	34818250	34803197	34700847	34774098.0
debca	100	765	18252	69.1	36.1	40.6	40011234	40031251	40133664	40058716.3

Table A.4.1

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
daecb	21	73	844	65.9	39.2	50	1018715	1008107	1028888	1018570.0
dceab	22	77	813	66.1	39.3	46.8	1049809	1037523	1059381	1048904.3
adebc	25	78	768	61.7	39.8	40.5	1032565	1068761	1054501	1051942.3
dceba	22	76	797	65.4	38.5	46.8	1023346	1021535	1118337	1054406.0
adecb	25	78	784	61.7	39.1	35.7	1049187	1050730	1066640	1055519.0
dcaeb	22	83	839	68.1	41.4	45.6	1074525	1056948	1087006	1072826.3
daceb	21	78	887	70	43	41.5	1100038	1078899	1090903	1089946.7
adceb	25	83	807	65.9	44.6	36.7	1061854	1061647	1158271	1093924.0
daebc	21	73	828	66.5	39.5	47.8	1055385	1043803	1224381	1107856.3
aecbd	26	91	933	61.7	40.2	41.9	1134899	1127360	1136669	1132976.0
cdeab	26	87	917	65.8	39.4	42.6	1137049	1132162	1143282	1137497.7
acebd	26	88	944	68.5	45.3	42.9	1131473	1134663	1147127	1137754.3

decba	22	86	1002	66	40	47.7	1125007	1128711	1170005	1141241.0
debca	22	85	1002	65.8	39.5	47.7	1138589	1135964	1159997	1144850.0
aebdc	26	92	945	63.4	40.9	37.2	1138500	1154787	1157338	1150208.3
aecdb	26	92	945	62.3	39.7	39.5	1125125	1126749	1215564	1155812.7
deacb	22	88	1034	65.5	40.5	38.6	1129498	1141091	1227174	1165921.0
decab	22	87	1018	65.8	39.1	43.2	1214607	1148875	1143587	1169023.0
cdaeb	26	93	911	66.2	39.7	40.4	1171165	1174408	1177802	1174458.3
debac	22	86	1018	66.2	39.7	43.2	1228367	1159937	1160482	1182928.7
deabc	22	88	1034	65.7	41.5	36.4	1235434	1148001	1168004	1183813.0
aedbc	26	93	961	63.1	41.3	37.2	1145665	1225174	1189124	1186654.3
aedcb	26	93	961	62.5	40.4	39.5	1128667	1292381	1147964	1189670.7
acdeb	26	95	935	66.9	46.6	38.8	1135832	1288096	1152950	1192292.7
cebad	26	95	1042	65.6	37.9	43.2	1191923	1182257	1207709	1193963.0
aebcd	26	91	929	62.7	40.7	39.5	1120902	1269603	1198830	1196445.0
acedb	26	89	1008	68.4	45.2	47.6	1147275	1318082	1132056	1199137.7
ceabd	26	96	1058	65.8	38.3	40.9	1193954	1209091	1209221	1204088.7
caebd	26	93	1060	67.2	40	39.1	1208220	1204179	1248370	1220256.3
cedab	26	97	1106	65.3	38.4	36.4	1221907	1223376	1243987	1229756.7
caedb	26	94	1112	68.6	41.6	47.8	1241054	1241944	1263390	1248796.0
cdeba	26	86	869	62.5	35.6	40.4	1283110	1212834	1308828	1268257.3
dcabe	24	118	1206	71.4	47.5	48.6	1266505	1264058	1282192	1270918.3
cadeb	26	100	1067	67.3	42.6	32.1	1368709	1216189	1239486	1274794.7
dacbe	23	113	1250	73.4	49.6	44.1	1271402	1274796	1290710	1278969.3
adcbe	27	118	1194	70.7	51.2	34.4	1282665	1284059	1297390	1288038.0
dcbea	26	107	1160	72.6	47.3	41.4	1238518	1234877	1407967	1293787.3
cedba	26	96	1074	65.7	38.8	38.6	1355857	1306055	1220654	1294188.7
adbec	28	106	1191	69.3	49	38.8	1320181	1294748	1317177	1310702.0
dabec	24	101	1251	72.2	47.3	37.7	1369087	1272248	1299236	1313523.7
cebda	26	95	1042	65.6	38.3	43.2	1356143	1363949	1220567	1313553.0
ceadb	26	97	1106	65.1	38	34.1	1378506	1325255	1256823	1320194.7
dbeca	27	95	1357	71.3	46	51.1	1336966	1340037	1353172	1343391.7
dbeac	27	96	1373	71.5	46.3	46.8	1358182	1349718	1366986	1358295.3
acdbe	28	130	1366	71.1	51.5	42.2	1360469	1368716	1381566	1370250.3
cdabe	28	128	1278	70.6	46.2	47.2	1365279	1370119	1384471	1373289.7
aced	30	131	1415	72.5	51.3	36.7	1392074	1393879	1405333	1397095.3
cdbea	30	117	1216	71.2	45.3	46.6	1326869	1410891	1482367	1406709.0
ebcad	29	103	1367	59.6	34.4	30.6	1412011	1403298	1422159	1412489.3
edbca	29	107	1415	60	36.3	32.7	1414286	1407944	1429508	1417246.0
ebcda	29	103	1367	59.6	34.3	30.6	1410012	1410826	1432537	1417791.7
ecabd	29	108	1399	59.5	33.2	34.7	1413665	1411281	1446469	1423805.0
ecbda	29	107	1383	59.8	34.2	26.5	1416657	1426881	1449928	1431155.3
ebacd	29	104	1383	59.9	34.9	30.6	1422838	1422365	1460611	1435271.3
edacb	29	110	1447	60.2	36.5	32.7	1425106	1429347	1459449	1437967.3
eabdc	29	109	1415	59.7	35.9	26.5	1431319	1448330	1453934	1444527.7
ebdac	29	104	1399	60	35.6	28.6	1439466	1452993	1456469	1449642.7
abecd	31	119	1520	71.8	48.3	40.5	1442690	1444409	1481813	1456304.0
eacbd	29	108	1399	59.5	34.2	30.6	1508470	1424130	1437093	1456564.3
ecdab	29	108	1399	59.5	33.3	30.6	1419084	1425161	1530885	1458376.7

dcbae	28	143	1530	72.1	49.2	51.3	1455835	1449241	1471191	1458755.7
ebdca	29	103	1383	59.8	35.2	30.6	1425741	1519182	1444841	1463254.7
abedc	31	120	1520	71.5	47.3	38.1	1454307	1464621	1480393	1466440.3
edcab	29	109	1447	60.2	35.2	30.6	1462899	1457853	1481109	1467287.0
eabcd	29	108	1399	59.5	34.7	28.6	1527980	1439142	1441663	1469595.0
dabce	26	136	1586	71.5	49.7	47.1	1471528	1461400	1484546	1472491.3
edcba	29	108	1415	59.4	34.8	30.6	1435313	1507022	1476506	1472947.0
cbead	33	128	1493	72.7	44	40.4	1444957	1509540	1466012	1473503.0
adbce	30	141	1542	70	50.9	45.3	1470727	1467011	1490330	1476022.7
cadbe	28	135	1498	70.9	47.7	41.2	1466091	1473231	1490835	1476719.0
ecbad	29	107	1383	59.8	34.6	28.6	1577957	1423108	1436245	1479103.3
edabc	29	110	1447	59.8	35.9	30.6	1481600	1471463	1484389	1479150.7
ebadc	29	105	1399	59.5	35	26.5	1607680	1436771	1444495	1496315.3
ecdab	29	109	1415	59.7	35.1	28.6	1599368	1437676	1456839	1497961.0
eadcb	29	110	1431	59.7	35.7	26.5	1447958	1589039	1467339	1501445.3
ecadb	29	109	1415	59.6	34.8	32.7	1427725	1633328	1449445	1503499.3
cbeda	33	128	1461	72.3	44.2	36.2	1451868	1604064	1459252	1505061.3
cdbae	32	153	1586	70.7	47.4	48.7	1530177	1523599	1551075	1534950.3
edbac	29	108	1431	60.3	36.9	34.7	1455304	1559623	1620028	1544985.0
cabed	30	136	1531	72.3	47.2	39.6	1485613	1665136	1503611	1551453.3
dbcea	31	127	1704	72.2	48.8	51.7	1543061	1544834	1579096	1555663.7
bedac	24	88	1682	69.6	43.8	47.7	1565944	1564707	1542530	1557727.0
bedca	24	87	1666	69.7	43.6	45.5	1555077	1558163	1569240	1560826.7
eadbc	29	110	1431	59.6	34.7	30.6	1452240	1531267	1707153	1563553.3
becad	24	87	1678	70.1	42.3	43.2	1576713	1560607	1577229	1571516.3
beacd	24	88	1686	69.9	42.9	40.9	1563215	1564426	1587314	1571651.7
becda	24	87	1678	70.3	42.9	43.2	1560180	1576910	1590630	1575906.7
eadcb	29	109	1431	59.6	34.9	28.6	1441857	1826627	1460911	1576465.0
beadc	24	89	1682	69.6	42.6	45.5	1563208	1587074	1580288	1576856.7
acbde	32	167	1758	71.6	52.3	42.2	1579287	1594403	1596848	1590179.3
dbaec	30	126	1799	72.2	47.8	49.1	1593338	1589422	1689561	1624107.0
cabde	32	172	1898	71.2	48.7	41.2	1697588	1687252	1701148	1695329.3
abdec	34	149	1943	71.2	50.4	40.8	1709301	1712661	1731227	1717729.7
abcd	35	162	1991	71.4	51.1	42.9	1734517	1750606	1755121	1746748.0
cbdea	37	160	1824	72.2	47.4	43.1	1841949	1818729	1679837	1780171.7
bdeca	29	101	2029	70.6	45	53.2	1772519	1821019	1787419	1793652.3
bdeac	29	102	2045	70.7	45.2	51.1	1787342	1791331	1812829	1797167.3
cbaed	38	173	1951	71.2	46.2	42.1	1920446	1757669	1773669	1817261.3
dbcae	34	165	2074	72.1	49.9	54	1847826	1850194	1788763	1828927.7
bceda	31	124	2085	70.8	43.7	42.6	1847334	1846541	1936149	1876674.7
dbace	32	161	2150	72.3	49	47.2	1964242	1808834	1873436	1882170.7
bcead	31	124	2105	70.9	43.3	46.8	1864912	1943725	1864542	1891059.7
cbdae	40	197	2194	72	49.6	48.7	1899471	1895283	1948170	1914308.0
abcde	37	198	2346	70.7	50.8	43.8	1965219	1950001	1968374	1961198.0
baedc	29	121	2260	70.8	44	43.5	1907694	1905755	2083610	1965686.3
baecd	29	120	2276	71.2	44.6	43.5	1912846	1936077	2053040	1967321.0
cbade	40	209	2318	70.5	48.2	43.1	1975001	1977977	1989698	1980892.0
abdce	36	184	2294	70.8	50.3	46.9	1910046	1905742	2169032	1994940.0

bdcea	33	133	2424	70.8	47	46.6	2016377	2104627	2192486	2104496.7
bdaec	32	132	2487	71	45.7	45.6	2036409	2049512	2249838	2111919.7
badec	32	150	2691	70.6	46.1	52.8	2143645	2140155	2146451	2143417.0
bcdea	35	156	2440	70.2	47.4	43.1	2208775	2194729	2047696	2150400.0
bdcae	39	174	2762	70.8	48.1	51.3	2219681	2237628	2238524	2231944.3
bdace	34	167	2838	71.2	48	51.4	2237549	2338648	2252217	2276138.0
bcaed	38	171	2563	70.6	47	40.4	2289780	2229892	2332415	2284029.0
bcdae	40	195	2862	70.8	48.4	50	2353953	2278320	2299593	2310622.0
baced	33	163	2799	71.9	47.5	45.3	2215866	2316825	2448484	2327058.3
bcade	40	207	2942	69.9	48.2	47.2	2331252	2328076	2353973	2337767.0
badce	34	185	3106	71.1	47.5	50	2354436	2366107	2398471	2373004.7
bacde	35	199	3138	70.9	48	48.5	2454747	2446608	2476949	2459434.7

Table A.4.2

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
daecb	21	73	844	65.9	39.2	50	1018715	1008107	1028888	1018570.0
daceb	21	78	887	70	43	41.5	1100038	1078899	1090903	1089946.7
daebc	21	73	828	66.5	39.5	47.8	1055385	1043803	1224381	1107856.3
dceab	22	77	813	66.1	39.3	46.8	1049809	1037523	1059381	1048904.3
dceba	22	76	797	65.4	38.5	46.8	1023346	1021535	1118337	1054406.0
dcaeb	22	83	839	68.1	41.4	45.6	1074525	1056948	1087006	1072826.3
adebc	25	78	768	61.7	39.8	40.5	1032565	1068761	1054501	1051942.3
adecb	25	78	784	61.7	39.1	35.7	1049187	1050730	1066640	1055519.0
adceb	25	83	807	65.9	44.6	36.7	1061854	1061647	1158271	1093924.0
aecbd	26	91	933	61.7	40.2	41.9	1134899	1127360	1136669	1132976.0

Table A.5

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
bdca	8	42	413	64.7	36.1	52.6	808468	810025	810882	809791.7
dbca	8	42	413	64.1	37.7	55.3	828178	828430	811169	822592.3
dcba	8	44	447	66.5	38.7	57.5	836443	835253	832277	834657.7
bcda	8	44	495	63.8	37.7	47.5	858173	854544	853509	855408.7
cdba	8	45	481	67.1	38.1	47.6	863523	866845	865364	865244.0
cbda	8	45	529	67.1	40.1	45.2	868099	870495	868253	868949.0
dcab	8	48	663	73.7	50.2	57.5	905549	908542	901106	905065.7
bdac	8	45	645	74	47.5	52.6	912222	910109	923137	915156.0
dbac	8	45	645	73.7	48.2	52.6	901083	990725	912624	934810.7
cdab	8	49	681	73.4	48.9	45.2	944253	930603	944264	939706.7
bcad	8	56	775	71.7	48.2	52.5	968334	971886	977154	972458.0
cbad	8	57	809	73.7	49.4	47.6	990297	989539	984408	988081.3
dabc	8	51	1173	80.6	56.4	57.4	1112160	1204259	1137501	1151306.7
cabd	8	62	1241	77.3	52.5	52	1173359	1172332	1181811	1175834.0
dacb	8	52	1167	79.8	55.5	52.1	1283132	1134196	1122406	1179911.3
cadb	8	54	1161	77.3	52.7	50	1133898	1135717	1294639	1188084.7
badc	8	55	1333	79.9	53.5	57.4	1197144	1192472	1192214	1193943.3

bacd	8	64	1407	78.9	55.8	52.1	1240350	1240186	1249274	1243270.0
adcb	8	59	2023	77.9	47.8	51.4	1595438	1587834	1594238	1592503.3
acdb	8	60	1945	77.8	51.3	45.5	1551383	1543381	1705499	1600087.7
adbc	8	58	2077	78.8	46.3	52.6	1598581	1747552	1596973	1647702.0
abdc	8	62	2221	78.4	46.6	52.6	1661834	1662222	1678841	1667632.3
abcd	8	71	2279	77.5	47.9	51.4	1697064	1694600	1684016	1691893.3
acbd	8	68	2073	77.8	48.2	45.5	1773695	1742824	1583036	1699851.7

Table A.6

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
bdcea	10	64	640	67	40.1	50.9	996192	993358	990033	993194.3
ecdba	9	59	688	67	39.9	56.4	992102	993085	1002976	996054.3
bcdea	10	64	656	67.2	41.3	45.5	998888	999015	1013127	1003676.7
cedba	10	62	689	69.6	42.7	48.2	1013236	1013533	1009622	1012130.3
dbcea	10	64	673	67.1	40.6	48.2	1002349	1017189	1023591	1014376.3
cdeba	10	63	706	70.3	42.9	52.6	1014959	1020248	1008446	1014551.0
cdbea	10	65	642	70.1	43.1	47.4	990133	988834	1075983	1018316.7
edcba	9	57	752	66.6	40.5	56.4	1015002	1016131	1025514	1018882.3
ecbda	9	59	719	66.8	41.5	51.9	1028974	1022913	1021813	1024566.7
bceda	10	62	735	67.9	42.3	50	1031755	1031659	1037038	1033484.0
cebda	10	62	704	69.4	43.2	49.1	1090614	1006779	1003387	1033593.3
edbca	9	57	751	66	40.5	55.6	1033804	1035250	1035521	1034858.3
bdeca	10	62	687	67.3	41.4	50	1004770	1087738	1014036	1035514.7
bedca	10	60	734	66.4	41.5	50.9	1049423	1027799	1033219	1036813.7
ebcda	9	58	750	67.2	42.2	54.7	1038393	1036007	1043291	1039230.3
dcbea	10	64	674	67.8	40.3	49.1	1060821	1005212	1066229	1044087.3
dceba	10	62	722	68	40.4	52.6	1024760	1025322	1101267	1050449.7
bdcae	9	65	808	72.1	47	50.9	1042422	1050186	1061649	1051419.0
cbdea	10	65	673	69.7	45.1	48.2	1000367	1165510	998960	1054945.7
decba	10	59	785	68.1	42.3	53.6	1050688	1072041	1048015	1056914.7
cbdae	9	66	825	74	48.3	50	1046609	1033622	1100679	1060303.3
bcdae	9	65	808	71.8	47.5	47.3	1067180	1059667	1054630	1060492.3
dcbae	9	65	826	72.1	46.5	47.4	1059058	1062525	1060333	1060638.7
ebdca	9	58	734	65.8	40.9	52.8	1081524	1083833	1021231	1062196.0
debca	10	59	784	67.5	42.8	54.6	1039786	1042721	1104630	1062379.0
becda	10	60	750	67.7	43.1	52.8	1043836	1154078	1039913	1079275.7
dbcae	9	65	841	71.9	47.1	46.4	1121480	1068836	1057590	1082635.3
cbeda	10	63	736	69.9	44.1	47.3	1201962	1040725	1023699	1088795.3
cdbae	9	66	810	74.2	47.8	47.4	1138685	1086727	1047254	1090888.7
dbea	10	62	720	67.4	41.8	47.3	1188748	1086546	1030994	1102096.0
bdeac	10	64	951	73.9	49.9	51.9	1102964	1105014	1099776	1102584.7
cedab	10	66	921	74.3	51.3	48.2	1092314	1113936	1108371	1104873.7
dbeac	10	64	1000	73.9	50.5	49.1	1112859	1113035	1116765	1114219.7
bedac	10	62	982	72.6	49	50.9	1114441	1117901	1112307	1114883.0
edcab	9	61	984	71.8	49.3	56.4	1116326	1122587	1109121	1116011.3
cdeab	10	67	938	74.8	50.6	50.9	1161095	1093418	1098179	1117564.0
decab	10	63	1017	72.7	50.3	53.6	1200096	1101035	1137376	1146169.0

dceab	10	66	954	73	49.7	47.4	1220371	1136727	1120968	1159355.3
cebad	11	74	1072	75.8	52.1	45.5	1157780	1155929	1167814	1160507.7
ebdac	9	60	982	69.4	46.2	50.9	1256546	1125393	1101238	1161059.0
ecdab	9	63	920	72.5	49.7	52.7	1095348	1262340	1157082	1171590.0
ecbad	10	71	1071	74.4	50.7	51.9	1152533	1154998	1218625	1175385.3
cdabe	9	67	1146	78.7	54.4	53.9	1172030	1177623	1178820	1176157.7
edbac	9	59	999	69.5	45.9	50	1141115	1126462	1285494	1184357.0
bdace	9	66	1104	76.7	52.6	57.1	1168085	1168919	1229116	1188706.7
dbaec	10	67	1236	76.5	53	52.2	1212282	1214036	1210415	1212244.3
cdaeb	10	70	1194	77.1	54.4	47.7	1214947	1214800	1215267	1215004.7
becad	11	72	1118	74.6	51.4	49.1	1197668	1264246	1185213	1215709.0
dbace	9	66	1169	76.8	52.8	56.3	1186658	1267498	1204010	1219388.7
debac	10	61	1048	73.4	50.1	52.7	1160555	1220701	1303948	1228401.3
cbade	10	68	1297	80	56.8	51.6	1242072	1245530	1242658	1243420.0
ebcad	10	70	1118	74.3	51.4	50.9	1234551	1336069	1171738	1247452.7
bcade	10	67	1296	78.7	55.5	54	1257877	1250352	1249708	1252645.7
dcabe	9	66	1146	76.8	51.8	52.3	1198776	1191858	1377282	1255972.0
bdaec	10	67	1203	76.7	53.1	54.6	1297488	1269570	1209234	1258764.0
cbead	11	75	1088	76.2	52.2	50.9	1176204	1231969	1379339	1262504.0
bcead	11	74	1087	74.6	50.7	48.2	1194020	1353424	1262101	1269848.3
dcaeb	10	69	1274	76.3	53.1	47.7	1257363	1342554	1311239	1303718.7
ecadb	10	72	1456	76.7	54	54	1347403	1374422	1335475	1352433.3
beadc	13	71	1538	76.5	54.2	49.2	1346288	1352937	1368509	1355911.3
bcaed	12	78	1499	77.5	53.6	43.9	1369666	1391323	1363267	1374752.0
ceadb	11	75	1457	77.8	55	51.6	1491444	1320350	1325850	1379214.7
deacb	11	68	1545	77.8	55.6	45.3	1393000	1341781	1411227	1382002.7
cbaed	12	79	1516	78.7	55.3	49.3	1444473	1342130	1359687	1382096.7
deabc	11	66	1532	76.2	52.8	47.8	1356159	1434739	1357040	1382646.0
dabce	10	69	1685	80	55.9	59.5	1402322	1387855	1388649	1392942.0
dacbe	10	69	1706	80.7	56.7	56.8	1417092	1415612	1408607	1413770.3
ceabd	12	83	1596	78.5	53.8	49.3	1396042	1463896	1390418	1416785.3
edacb	10	66	1544	77.8	55.2	49.2	1349732	1567069	1346614	1421138.3
ebadc	12	69	1634	78.9	56.8	52.3	1406539	1393182	1474855	1424858.7
edabc	10	64	1563	78.1	54.1	51.5	1580803	1360428	1359524	1433585.0
beacd	14	81	1706	77.8	55.3	44.6	1436991	1436772	1432475	1435412.7
ecabd	11	80	1595	77.5	52.9	54.6	1395731	1394823	1553204	1447919.3
dabec	11	70	1688	79.2	56.1	56.3	1414449	1575516	1414854	1468273.0
cadbe	10	70	1690	81.1	56.9	55.6	1419945	1422922	1581649	1474838.7
badce	12	71	1700	80.2	57.3	60.2	1434177	1417107	1612952	1488078.7
ebacd	13	79	1818	78.5	54.9	50.8	1549172	1466669	1457043	1490961.3
badec	13	72	1735	79.5	57.6	58.1	1435609	1524106	1592936	1517550.3
cadeb	11	73	1818	80.5	57.1	49.4	1642602	1489480	1483936	1538672.7
cabde	11	71	1829	82.2	57.4	57.1	1652086	1491694	1484414	1542731.3
daceb	11	72	1786	79.9	56.6	51.9	1640878	1532938	1461836	1545217.3
bacde	13	72	1844	81.2	57.9	59	1503018	1649501	1496719	1549746.0
daecb	12	74	2013	79.6	57.8	48.8	1554308	1550789	1562642	1555913.0
daebc	12	72	2016	79.8	57.2	50.6	1557376	1551536	1569613	1559508.3
baced	15	83	2095	80.3	56.6	55.8	1604919	1604147	1622749	1610605.0

caedb	12	79	2069	79.8	56.3	52.4	1614526	1610137	1609949	1611537.3
cabed	13	82	2096	81.3	55.8	52.9	1589902	1735979	1588695	1638192.0
caebd	13	87	2192	80.1	55.6	54	1633138	1715538	1628253	1658976.3
eabdc	15	78	2282	80.6	57.5	52.8	1761312	1661624	1672096	1698344.0
eacdb	13	80	2260	79.1	56.7	54.2	1696391	1733384	1677219	1702331.3
eadbc	13	74	2191	79.1	55.6	54.7	1660727	1652063	1801252	1704680.7
eabcd	16	88	2354	80	56.1	53.9	1709963	1716157	1712633	1712917.7
baedc	16	78	2154	80.4	59	51.7	1877873	1631089	1634721	1714561.0
eacbd	14	88	2335	79.7	56.3	51.2	1712986	1733129	1711255	1719123.3
eadcb	13	76	2220	79	56	53	1668206	1836719	1670207	1725044.0
baecd	17	88	2290	80	57.6	53.9	1691932	1693660	1851686	1745759.3
adbec	14	77	2388	79.2	51.4	55.7	1765903	1769125	1763532	1766186.7
adbce	13	76	2401	79.5	50.9	60.7	1785464	1784747	1788321	1786177.3
abdec	16	79	2439	79.7	53.2	56.8	1797624	1799387	1793574	1796861.7
acdbe	13	76	2438	80.3	51.9	56.9	1791538	1793685	1825058	1803427.0
abdce	15	78	2452	80.2	52.5	60.9	1873018	1850428	1790732	1838059.3
adceb	14	79	2550	78.9	52.3	54.1	1921048	1843397	1838540	1867661.7
acbde	14	77	2593	81.5	52.6	60.7	1869675	1874264	1872581	1872173.3
adcbe	13	76	2454	80.1	51.5	56	1803838	1969807	1850487	1874710.7
adebc	15	79	2636	79.4	52.4	54.8	1896851	1895584	1910612	1901015.7
abcde	16	79	2692	81.3	53.5	57.4	1915593	1928397	1919784	1921258.0
adecb	15	81	2713	79.4	53.5	56.3	1913514	1935709	1921876	1923699.7
abedc	19	85	2778	80.2	56.3	57	1933665	1938306	1935705	1935892.0
acedb	15	85	2849	79.4	53	58	2004936	1998014	2012482	2005144.0
abcd	18	90	2783	80.3	53.2	55.9	1934898	2167265	1929154	2010439.0
acdeb	14	79	2566	79.5	52.6	57.8	2018847	2096103	2019321	2044757.0
acebd	16	93	3036	79.9	51.8	58.3	2050296	2063353	2077820	2063823.0
aecdb	17	89	3044	78.7	52.1	56.5	2068014	2064040	2062497	2064850.3
aced	16	88	2860	80.7	52.9	56.5	2068215	2144073	2006917	2073068.3
aebdc	19	87	3118	79.2	52.7	61.2	2081544	2086860	2099052	2089152.0
aedbc	17	83	2975	78.5	51.8	58.5	2091134	2127152	2062248	2093511.3
abecd	20	95	3122	80.5	53.3	58.7	2101812	2276965	2180800	2186525.7
aedcb	17	85	3324	79.4	53.8	54.8	2224582	2208184	2203326	2212030.7
aecbd	18	97	3231	78.6	52.1	55.9	2389007	2208196	2139586	2245596.3
aebcd	20	97	3270	79.3	52.9	57	2540220	2153066	2211630	2301638.7

Table A.7

Order	FNC	TNC	CTA	ADD	MULT	KRON	TIME	TIME2	TIME3	AVG
dbcae	9	90	1273	77.1	54.4	67.2	1172308	1159344	1153732	1161794.7
bdcae	10	90	1235	76.5	52.2	62.1	1146739	1143339	1297204	1195760.7
dcbae	9	89	1413	79	57.9	67.2	1219243	1208835	1209714	1212597.3
bdcea	10	103	1433	76.4	54.4	65.6	1217612	1217785	1211042	1215479.7
beacd	9	71	1517	81	51.3	60.5	1228393	1253675	1227256	1236441.3
acebd	9	71	1585	82.3	55	60.9	1239685	1244085	1237063	1240277.7
dbcea	9	103	1487	76.9	54	70	1241204	1248056	1245107	1244789.0
eacdb	10	69	1533	82.6	56.5	64.5	1244298	1239929	1256755	1246994.0
caedb	10	70	1569	81.7	54.5	65.6	1253534	1258191	1249740	1253821.7

aecdb	10	69	1591	81.8	52.2	60	1255532	1259261	1247587	1254126.7
eabcd	9	71	1635	83	58.1	62.9	1274363	1272535	1269613	1272170.3
ebacd	9	71	1639	82.8	56	61.4	1273924	1269149	1280882	1274651.7
cdbae	10	89	1439	78.5	55.1	65.7	1379797	1226808	1232407	1279670.7
caebd	9	71	1563	82.5	57.8	65.5	1285545	1342918	1290197	1306220.0
acdbe	10	86	1669	79.3	55.3	69.7	1309310	1304595	1306596	1306833.7
acedb	10	70	1575	81.7	53.1	65.7	1268619	1347463	1327122	1314401.3
dcbea	9	102	1675	78.6	57	68.6	1315448	1327129	1307122	1316566.3
cadeb	10	79	1761	80.5	55.3	68.8	1317902	1321768	1314907	1318192.3
dcabe	9	90	1669	80.7	60.6	64.1	1298885	1379439	1306813	1328379.0
cdabe	10	90	1727	80.1	57.3	65.7	1329190	1327541	1336430	1331053.7
cadbe	10	86	1631	79.5	57.8	64.3	1278635	1438081	1276713	1331143.0
aebcd	9	71	1653	82.1	54.8	65.6	1431192	1278199	1286447	1331946.0
beadc	10	85	1695	81	50.3	62.9	1299815	1299385	1401118	1333439.3
aecbd	9	70	1737	83	53.8	57.8	1303446	1397298	1309307	1336683.7
aebdc	10	85	1651	81.1	52.6	60.3	1436752	1284462	1289207	1336807.0
eacbd	9	70	1639	83.1	58.7	67.1	1447241	1284376	1289248	1340288.3
cdbea	10	102	1765	78.4	55.1	69.7	1341742	1350239	1344478	1345486.3
bdeac	10	107	1615	76.3	53.4	64.3	1299428	1451574	1286738	1345913.3
acdeb	10	79	1671	80	51.4	68.6	1301997	1465059	1297202	1354752.7
eabdc	10	85	1665	81.7	56.2	51.6	1292601	1479621	1304354	1358858.7
dcaeb	9	83	1671	80.8	57.8	63.8	1464371	1312450	1304497	1360439.3
bedac	10	101	1791	79.1	54.2	67.1	1357182	1371805	1357387	1362124.7
dbeac	9	107	1653	76.8	53.9	65.8	1394972	1316539	1410077	1373862.7
bdeca	10	112	1745	77.9	56	65.6	1352309	1359823	1417509	1376547.0
ebadc	10	85	1793	82.2	55.4	57.8	1492630	1321438	1319724	1377930.7
bedca	10	106	1865	78.5	52	60.9	1387009	1384770	1382906	1384895.0
ebdac	10	101	1865	78.6	54.2	62.5	1382187	1394133	1383465	1386595.0
cdaeb	10	83	1761	80.4	55.6	64.1	1335652	1349496	1491641	1392263.0
ebdca	10	106	1859	79.3	56.4	56.9	1390717	1396906	1390174	1392599.0
dbeca	9	112	1779	77.7	55.1	68.6	1443835	1387357	1379431	1403541.0
bcdae	10	101	1969	81.4	59.6	69.4	1409562	1417151	1415232	1413981.7
cbdae	10	101	2001	81.3	58.9	66.7	1441164	1454785	1444461	1446803.3
acbde	10	100	2103	81.5	57.5	70.5	1472386	1468427	1481173	1473995.3
bcdea	10	114	2119	81.3	58.9	70.5	1478086	1479884	1480896	1479622.0
cbdea	10	114	2087	80.3	57	66.7	1483033	1483589	1483644	1483422.0
acbed	9	94	2063	81.3	53.7	70.5	1441866	1475095	1611797	1509586.0
baedc	10	98	2225	82.6	56.2	72.2	1492748	1649858	1496646	1546417.3
cabde	10	100	2129	82	60.2	65.3	1488763	1494377	1698152	1560430.7
abedc	10	98	2353	82.6	54.9	66.7	1572256	1563598	1555418	1563757.3
bdaec	10	138	2193	78.3	58.1	69.4	1621413	1550880	1526630	1566307.7
bdace	10	130	2193	79.7	59.5	69.4	1541460	1634230	1532122	1569270.7
dbaec	9	138	2279	78.5	57.5	69.2	1578163	1578041	1572687	1576297.0
dbace	9	130	2259	80	59.8	69.2	1567710	1639226	1567452	1591462.7
bcaed	9	110	2497	81.8	56	66.3	1631639	1631245	1622951	1628611.7
aedbc	10	106	2497	82.7	61.6	66.7	1629312	1639371	1626278	1631653.7
cabed	9	94	2169	81.8	55.9	69.4	1511872	1497361	1898489	1635907.3
baecd	9	84	2255	83.7	57.3	64.1	1747907	1508319	1672887	1643037.7

abcd	9	84	2303	83.8	55.8	69.2	1529212	1705103	1714801	1649705.3
eadbc	10	106	2615	82.8	62.7	68	1669160	1654218	1670242	1664540.0
eadcb	10	91	2495	84.5	61.1	69.2	1617141	1776496	1610375	1668004.0
adcbe	10	103	2503	82.3	58.8	70.5	1612829	1780442	1618349	1670540.0
baced	9	106	2615	81	53.6	67.4	1681157	1672733	1670232	1674707.3
bacde	10	112	2611	81.8	58.7	68.6	1675648	1735409	1671963	1694340.0
dceab	9	109	2709	82.5	57.5	68.1	1708595	1713075	1706064	1709244.7
aedcb	10	91	2489	83.8	59.1	70.8	1768945	1602501	1757280	1709575.3
dacbe	9	103	2491	83.4	63.6	69.2	1624059	1638750	1869286	1710698.3
cbaed	9	110	2593	82	56.2	68.8	1689187	1676826	1775728	1713913.7
bcade	10	116	2737	81.4	57.6	61.3	1722299	1719014	1716477	1719263.3
adceb	10	96	2777	83.8	56.9	68.1	1728837	1722516	1715488	1722280.3
ecadb	10	88	2815	85.3	62.3	69.2	1726214	1722753	1732067	1727011.3
abcde	10	112	2719	82.1	57.5	68.6	1734783	1736022	1713238	1728014.3
cdeab	10	109	2767	82.1	55.2	65.4	1749657	1737937	1738337	1741977.0
ceadb	10	88	2735	83.7	56.6	62.8	1855964	1698970	1688032	1747655.3
ecabd	9	89	2881	85.9	63.5	66.7	1757915	1757633	1758238	1757928.7
daceb	9	96	2757	84.2	61.4	66.7	1880645	1716538	1706560	1767914.3
abcd	9	106	2823	82.9	55.5	67.4	1744768	1748747	1832050	1775188.3
becad	9	108	2735	83.7	60.2	65.4	1721273	1815505	1793502	1776760.0
ceabd	9	89	2873	84.7	57.1	62.5	1743856	1755880	1902751	1800829.0
ebcad	9	108	2809	82.6	59.5	63.9	1751234	1752028	1909674	1804312.0
abdce	10	137	2969	82.2	55.8	65	1802063	1804663	1815773	1807499.7
abdec	10	145	2985	79.8	53.7	68.8	1816657	1817144	1814776	1816192.3
badce	10	137	3049	82.6	57.4	65	1827147	1837614	1821152	1828637.7
ebcda	10	127	2977	82.7	61.4	65.3	1901353	1817606	1810799	1843252.7
cdeba	10	129	3031	82.2	57.6	68	1843964	1844830	1841427	1843407.0
becda	10	127	2951	82.3	58.3	62.8	1959879	1807543	1813572	1860331.3
dceba	9	129	2909	82.6	59	68.1	1859030	1814827	1937912	1870589.7
badec	10	145	3081	79.5	52.8	66.3	1844998	1852110	1931206	1876104.7
daebc	9	124	3161	81.9	53.1	65	1881872	1879602	1893105	1884859.7
debac	9	120	3051	83.3	59.7	70.5	1837253	1998342	1846153	1893916.0
bcead	9	125	3207	82.3	55.8	66.3	1894501	1896766	1894897	1895388.0
dabce	9	142	3079	81.7	59.1	67.4	1897768	1899483	1894860	1897370.3
dabec	9	150	3087	79.7	57	68.6	1886429	1899094	1909769	1898430.7
debca	9	125	3057	83.2	59.5	69.4	2009974	1854758	1853663	1906131.7
adebc	10	124	3241	81.3	50.2	65	1907657	1918339	1907402	1911132.7
edbac	10	120	3247	83.9	64.6	69.2	1923322	1918604	1918523	1920149.7
cbade	10	116	2861	83	59.9	66.3	2022775	1981863	1768129	1924255.7
daecb	9	109	3181	82.3	51.2	68.8	1875509	2041349	1871076	1929311.3
adecb	10	109	3313	81.8	47.3	61.3	1926807	1935765	1927454	1930008.7
adbce	10	142	3231	81.1	56.1	70.9	1992053	1911097	1909135	1937428.3
adbec	10	150	3103	79.1	54	69.8	2041369	1882089	1904804	1942754.0
deacb	9	110	3339	83.5	56.5	67.4	1953941	1949612	1945400	1949651.0
cbead	9	125	3303	82.4	57.4	61.6	1961991	1948722	1963162	1957958.3
bceda	10	144	3391	81.5	57.6	68.6	1996292	1983843	1989238	1989791.0
edbca	10	125	3073	83.4	64.4	65.3	2101654	2022584	1852603	1992280.3
cbeda	10	144	3507	81.2	57.5	66.3	2018912	2017721	2015428	2017353.7

edacb	10	110	3359	84.1	60.6	64	1954747	2041941	2107707	2034798.3
edcab	10	123	3673	84.2	62.5	66.3	2058440	2051706	2058058	2056068.0
decab	9	123	3705	83.9	59	65	2073294	2078574	2235929	2129265.7
deabc	9	125	3759	84.6	59.2	64	2261601	2104706	2096610	2154305.7
cedab	10	123	3959	82.5	56.5	66.3	2178745	2179792	2187770	2182102.3
edabc	10	125	3935	85	63.2	62.8	2324318	2184195	2170942	2226485.0
ecdab	10	123	3991	84.3	61.8	61.6	2191518	2190555	2353457	2245176.7
cebad	9	127	4145	84.2	61.9	63.8	2314781	2240386	2223665	2259610.7
cedba	10	143	4191	83	56.8	62.8	2283036	2287267	2277814	2282705.7
ecbad	9	127	4245	85.2	65.7	67.5	2280412	2287898	2317819	2295376.3
ecdba	10	143	4175	84.2	62.9	61.6	2276436	2289373	2356039	2307282.7
decba	9	143	4305	84.6	61.2	66.3	2309522	2314680	2302165	2308789.0
ecbda	10	146	4161	83.5	65.5	63.8	2454054	2287791	2274695	2338846.7
edcba	10	143	4421	85.7	65.2	68.8	2353701	2368389	2439198	2387096.0
cebda	10	146	4201	82.9	61.7	65	2278616	2438500	2451814	2389643.3