CS 392

Assignment 4

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11/18/18

1.

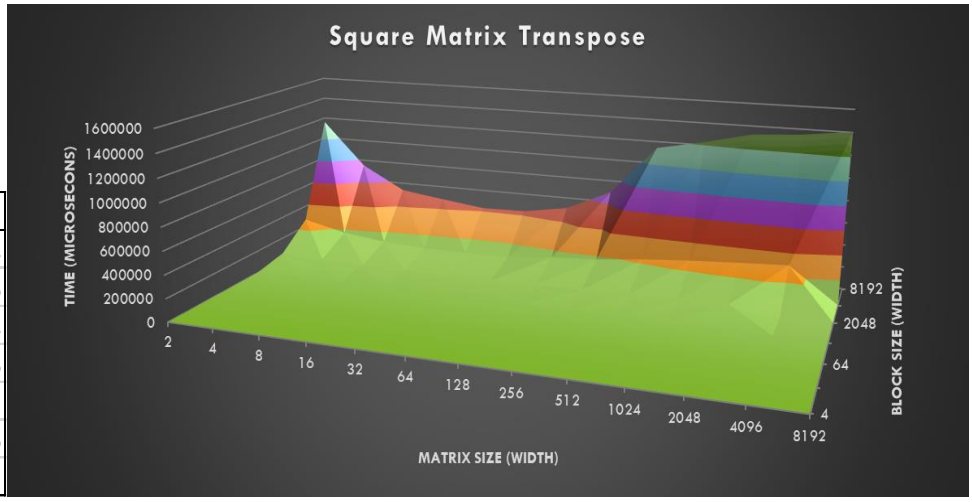
Question: Explain how the code becomes faster due to cache hits.

Answer:

Due to locality, the code becomes faster specifically because of an increase in cache hits. That is, the code is written in such a way that data in the cache is efficiently utilized in the transpose operation. The result is fewer cache misses (more cache hits) and therefore fewer calls to lower levels in the memory hierarchy to get the sequence of data that is missing in the current level of cache. It's faster to access data in the current memory level's cache than to request and retrieve it from the next level down.

Square Matrix Transpose														
		Block Sizes												
		2	4	8	16	32	64	128	256	512	1024	2048	4096	8192
Matrix Size	4	1	0.75											
	16	2.375	2.5	2.375	1.875									
	64	21.625	21	18.625	17.75	18.5	17.5							
	256	364.625	299.875	286	283.75	281.5	288.375	291.25	280.5					
	2048	52575.5	39889.625	29166.75	23853.125	22755.875	24779.25	29915	37492.125	45583.875	51275.625	57278.75		
	4096	265797.5	174747.25	125796.875	103427.5	103209.25	109365.75	150845	176307.375	221902.125	255926.25	282503.375	306052.75	
	8192	1160368	747178.625	530099.875	474558.375	423538.25	431156	500832.5	692331	1141496.625	1225117.625	1324240.125	1352188	1406259.75

Best Block	Matrix Size
4	4
16	16
64	64
256	256
32	2048
32	4096
32	8192



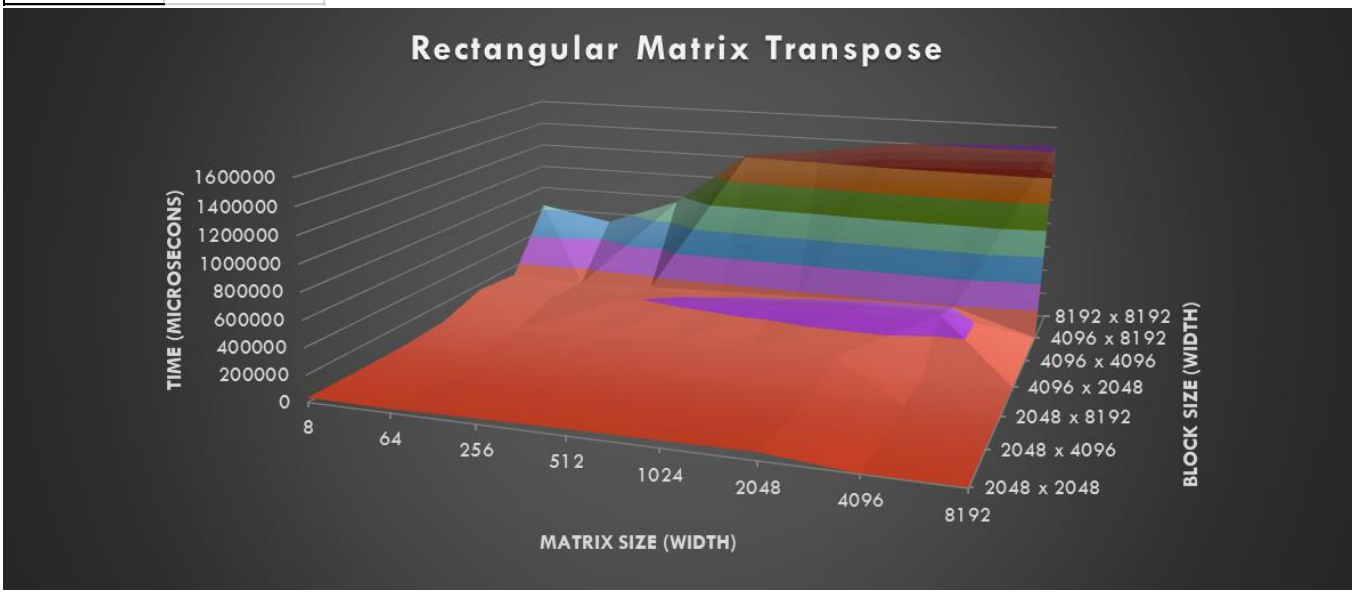
Timings:

	Matrix Size	Block Sizes												
	4	2	4											
		1	1											
		1	1											
		1	1											
Runs		1	1											
		1	1											
		1	0											
		1	0											
		1	1											
	16	2	4	8	16									
		2	2	2	2									
		3	3	3	2									
		2	2	2	2									
Runs		2	2	3	2									
		2	3	2	2									
		3	3	2	2									
		3	3	2	1									
		2	2	3	2									
	64	2	4	8	16	32	64							
		21	19	19	18	19	17							
		22	19	18	18	19	18							
		21	18	19	18	19	18							
Runs		22	19	18	18	18	18							
		22	19	18	17	19	17							
		21	19	19	18	18	17							
		22	19	19	18	18	17							
		22	36	19	17	18	18							
	256	2	4	8	16	32	64	128	256					
		337	379	283	277	277	273	294	276					
		405	290	282	313	285	274	271	282					
		383	288	279	273	296	327	268	293					
Runs		340	295	283	302	275	310	271	276					
		435	285	298	270	276	275	265	279					
		336	287	288	268	277	280	430	274					
		347	289	293	264	288	286	267	275					
		334	286	282	303	278	282	264	289					
	2048	2	4	8	16	32	64	128	256	512	1024	2048		
		52503	40222	29031	24052	22618	25374	29825	39204	47575	52191	61393		
		51335	38494	29018	23624	22696	24161	30634	34941	45988	49530	55824		
		52523	39389	29255	23846	22737	24341	30111	35964	48257	50152	59000		
Runs		53392	41559	27635	23796	22739	24686	29382	36844	49785	52166	56296		
		51788	40009	29552	23835	22365	25070	28688	37057	47858	51740	56494		
		54335	39969	29312	23407	22592	24979	30358	37516	40062	51944	55460		
		53784	39878	29074	23870	23373	24828	29049	38041	43476	50686	55291		
		50944	39597	30457	24395	22927	24795	31273	40370	41670	51796	58472		
	4096	2	4	8	16	32	64	128	256	512	1024	2048	4096	
		265096	173251	125069	104840	101008	106294	149057	160378	222284	258807	286027	291456	
		259975	173775	125242	103063	103409	103761	159254	177221	218293	253896	283753	312041	
		268187	174901	123789	102948	100982	104911	141156	186089	227101	262750	284264	313621	
Runs		273885	173586	124860	102724	102889	116846	146352	195855	217532	254117	276056	330672	
		269158	172714	129410	104448	103136	108124	149150	179256	222795	260256	285329	296318	
		264238	183115	130948	104495	104049	112481	155910	167290	226875	250072	276682	298069	
		260686	172337	123412	102889	104909	114181	150728	182266	218407	251561	273711	297111	
		265155	174299	123645	102013	105292	108328	155153	162104	221930	255951	294205	309134	
	8192	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192
		1157856	774262	536467	472378	421466	427584	499570	668367	1162723	1222121	1319586	1353878	1449796
		1161294	763176	529605	473992	433488	422559	500621	680491	1128442	1230230	1341858	1328761	1352316
		1141755	743124	534080	471849	431737	424721	491655	691844	1143148	1209618	1321239	1360433	1450034
Runs		1203387	742717	535908	474797	419627	429921	503566	694684	1142859	1214331	1310971	1433397	1418042
		1164944	744919	529204	470751	420393	432232	504924	700328	1131780	1228602	1328623	1342496	1429631
		1141550	730463	526288	484248	419662	449188	506477	726657	1133593	1234203	1333336	1336297	1342193
		1144906	740220	524562	473955	417605	425588	500547	712603	1148699	1215425	1310810	1336697	1446368
		1167252	738548	524685	474497	424328	437455	499300	663674	1140729	1246411	1327498	1325545	1361698

2.

Rectangular Matrix Transpose										
			8	64	256	512	1024	2048	4096	8192
Matrix Size	2048	2048	35370.38	30058.75	41269.75	48008.75	52440.5	58551.88		
	2048	4096	28841.5	24156.25	28698.13	30858.5	33700.5	37540.5		
	2048	8192	26027.13	20615	21907.88	24325.5	24338.625	26469.38		
	4096	2048	48086.75	38462.13	58773.13	69361.38	80142	90488.75		
	4096	4096	152440.8	130673.1	189580.4	231315.5	264662.375	304415.8	310435.3	
	4096	8192	121350.3	101195.3	126591.1	145980.8	164120.875	185767.9	192499.3	
	8192	8192	631386.9	522948.9	754400	1221812	1292686.38	1395559	1420440	1452770

Best Block	Matrix Size
64	2048
64	2048
64	2048
64	4096
64	4096
64	4096
64	8192



Timings:

	Matrix Size									
	2048	2048	8	64	256	512	1024	2048		
			35570	30141	44069	48651	51593	56909		
			35319	30253	41516	48793	52009	57395		
			36057	30028	41074	48436	52110	56135		
Runs			35048	29426	40675	46564	52489	57847		
			34815	30419	39653	48412	53197	58854		
			35272	30279	41896	47310	53166	57928		
			35288	29806	41417	49014	52604	59655		
			35594	30118	39858	46890	52356	63692		
	2048	4096	8	64	256	512	1024	2048		
			28467	23671	27553	30818	33191	37245		
			29644	23768	27843	33223	33871	36204		
			29057	24660	29682	30028	33661	37361		
Runs			28874	24217	28611	30045	33643	36862		
			28018	24115	28365	30566	33045	37545		
			28662	24264	28376	31533	34493	38498		
			29363	24481	30105	29872	33071	37186		
			28647	24074	29050	30783	34629	39423		
	2048	8192	8	64	256	512	1024	2048		
			25491	20499	21121	22819	24788	26478		
			25631	20321	23209	25571	24223	26058		
			26277	20658	21874	24336	24283	26781		
Runs			26657	20695	21084	24999	23807	26693		
			26359	20726	21310	22674	24057	27451		
			25832	20338	21732	24622	24842	25622		
			26133	20564	21462	24892	24881	26776		
			25837	21119	23471	24691	23828	25896		
	4096	2048	8	64	256	512	1024	2048		
			47023	39241	58512	70422	81043	89424		
			45771	38899	57772	70515	81144	89616		
			46632	38763	55766	70609	82344	89756		
Runs			46049	37402	57194	70117	79203	89471		
			46217	38763	56982	68013	79622	90021		
			45422	37072	62668	65514	79168	94841		
			46299	38988	60985	70211	78869	90472		
			61281	38569	60306	69490	79743	90309		
	4096	4096	8	64	256	512	1024	2048	4096	
			152355	127064	187478	228783	267173	305663	313508	
			152155	126058	187752	233750	264128	309004	320665	
			154203	131276	191269	231282	260373	303936	309754	
Runs			151386	136015	195856	232657	266599	303574	307754	
			153220	132773	191375	227948	259516	304240	307336	
			152234	132963	189241	226402	266401	305813	311904	
			153034	127353	180605	236618	269609	299206	303775	
			150939	131883	193067	233084	263500	303890	308786	
	4096	8192	8	64	256	512	1024	2048	4096	
			121688	103033	127380	144834	167255	181472	193717	
			120922	101898	125632	145972	164623	187348	192452	
			121352	101411	124160	150308	167477	191271	190311	
Runs			124031	102419	123325	143551	161594	182919	188606	
			119521	100197	130938	143656	161502	195103	200486	
			121167	101397	125577	147890	161760	182001	188857	
			121555	99361	130673	145880	164519	183634	191162	
			120566	99846	125044	145755	164237	182395	194403	
	8192	8192	8	64	256	512	1024	2048	4096	8192
			642031	520539	748600	1224273	1305113	1422453	1417199	1533329
			629534	523477	764844	1218246	1286706	1385708	1405983	1430315
			628434	516878	755463	1219525	1284689	1378850	1400557	1404187
Runs			634097	520727	759305	1221296	1311017	1386767	1432742	1400741
			628001	525856	757688	1207976	1281116	1392444	1422475	1515169
			627270	521104	768259	1225830	1281276	1414693	1412861	1508472
			630124	526307	728043	1229356	1306035	1391366	1426463	1422766
			631604	528703	752998	1227994	1285539	1392192	1445237	1407179

3. See Github: https://github.com/bormanjo/Systems-Programming/commits/master