

DIRECTED WORD CHAIN NETWORKS (PART 2)

LEONARD GORDON
Tucson, Arizona

This is one of a series of articles on directed word chain networks. The concept of a directed word chain network, together with definitions of various terms used to characterize such networks, was introduced in Part 1 of this series. The concept of a word chain dates back at least to Dudeney's 1925 book, The World's Best Word Puzzles (largely reprinted as 300 Best Word Puzzles by Dover in 1968).

This article is limited to regular (8,4) word chain networks. The eight-letter words used here come from Web 2, Web 3, OSPD, and Chambers Words, a list made from the Chambers Twentieth Century Dictionary. Most words can be found in Web 3. My database was extracted from a computerized OSPD list, then expanded by hand search of all the dictionaries including OSPD. The OSPD list (1978) derives from Web 3 (1961), but includes a significant number of relatively new words (a 1991 edition is available). 12000 Words, a supplement to Web 3, contributed a few new words, although most words found there are in OSPD. With respect to Web 3, I accepted words marked "often capitalized" but not "usually capitalized". Scottish and dialect words were accepted.

Eight-letter words were split whether the four-letter frags were words or not. A previous Word Ways article ("Ana-Gram-Mar Chains" November 1990) required that frags be common words, and classified them according to meanings relative to the eight-letter word. I did not do anything like that, but in fact all types of frags did show up.

Appendix A is a selection (read from left to right) of word chains obtained from a database of 2813 eight-letter words with 960 different frags. This is an abstract from the main network, far too complicated to diagram in full. All the chains are interconnected (though many cross-paths are not shown), and some sequences repeated. The four longest irreducible chains (RATS to PATE, VIOL to PATE, VIOL to BLES, and STEE to TOID) all take 17 steps. This is the one-way span of the network.

What is the two-way span? To aid in the search, some words in the diagram are written in caps; these cannot contribute to a loop in the core. For the others, CONE to BITS takes 10 steps, and BITS to CONE 13, for a round trip of 23; this is the two-way span. Some near-misses are PISH to CONE 14, CONE to PISH 8; MOTH to CONE 11, CONE to MOTH 10; BLES to CONE 12, CONE to BLES 10; and RATS to CONE 16, CONE to RATS 5. MOTH to GENT in 8, and GENT to MOTH in 10, is an interesting pair. Shifting this cycle

gets two irreducible chains of equal length (note how WOOD is used in both directions):

rice-bird-lime-wood-cock-crow-foot-sore-hawk-moth
moth-worm-wood-side-show-ance-rata-plan-gent-rice

The BLES-CONE loop also appears in Appendix A as an ENCE-CONE loop; this is also a shift in the cycle. A further shift produces two equal chains, but this is not valid, as CONE to BUCK can be reduced:

cone-head-land-wire-bars-poon-tang-ence-inte-grum-bles-buck
buck-wash-down-turn-over-free-zing-anas-arca-dias-pine-cone

Here are a few sequences that do not appear in Appendix A. Most are in the main network, but one or two are isolated. I came across the latter in my search; more undoubtedly exist.

surf-aces-cent-ring	tyro-sine-cure
down-cast-rate-able	broc-coli-near
bast-aard-wolf-rams	over-heat-hens
tire-dest-roys-ting	lime-quat-rain
nama-quan-dang-ling	mono-poly-gram-mars-hall
drop-kick-shaw-fowl	egla-tere-bene-fits-root
stam-pede-stal-wart	osna-burg-rave-lins-tock
tops-oils-kins-folk	fore-past-rami-form-ally-late
aspi-rata-plan-cher	spin-ally-late-bras-sage-rose
yest-reen-list-able	scim-iter-ance-stor-ming-ling
blue-gume-hoed-owns	half-lang-shan-tung-sten-tors-ions
cali-phal-ange-ring	
fool-scap-hoid-ened	
flat-beds-traw-lers	

bouf-fant	ails-ytes	heel	aman-dine-uric-emia	cana	ries
	asie-ntos		taps-ters		pina-fore

Of the 960 frags in my database, 119 can only begin, and 142 can only end a chain. 699 may do either. If we eliminate the terminal frags, then some of the others can no longer fill a dual role. Eliminating these and repeating the process four or five times winnows the 699 down to 507. These ideal 507 frags are the core of the network; any one can be reached from any other with an (8,4) word chain. The above two-way span is part of this core. Appendix B gives all 960 frags. Capital letters start the beginners and terminate the enders; those with the middle letters capitalized are the 192 dropouts (preceders and followers).

Using the full 960 list, a fan starting from any of the 507 core frags can reach (sweep) 660 others.

Although my objective when searching the dictionaries was to find eight-letter words that either contributed to the network span or were useful in forming rectangular arrays (discussed in a later article), I included some that seemed to have potential. Several didn't, and merely became appendages to the main network. These are not swept by fans originating within the core, but can become sources for fans. A fan starting with BARA sweeps 675; one start-

ing with THOU, 671; one starting with SOUP, 669; and one starting with ARRE, 667. Here are some details; others can be found in Appendix A.

	boos-ster--			root--
	mins-ter		tant-alum	inum
bara	rite-less-ness		soup-cons	pire
	ter		true-blue	caps--
	thea tres		bank-rupt	fins
	tric-home--	bars--	burr-ough-ting--	fish-
	thra sher--	thou-sand	burs-tone--	jack-
	wart		hogs-head--	stem-
			wich	

Most of the 507 core frags can be arranged in a single chain, but that job is not well suited for computer search, and is not for me in any case. On the other hand, the following are suited for computer search. The first is the longest chain in which all frags are in alphabetical order. The second chain uses 23 different starting letters for the frags:

ball-cock-crow-foot-hold-over-seer-ship-side-slip-slop-work

Vine-Yard-Land-Iron-Back-Slap-Jack-Roll-Over-Deck-Hand-Trap-
Nest-Able-Gate-Ward-Ency-Clic-King-Fish-Pole-Mist-Unes

Here are three palindromic chains. Appendix B gives a list of reversible words. A WORKHEAD (Web 3) is part of a lathe or other machine tool.

hang-over-turn-down-take
long-head-work-book-land-folk
come-down-take-over-burn-side-hill

The following looped chains have related four- or eight-letter end words. Both halves of each loop are of the same length. They are usually as short as I could find, although the length of one of the halves was often adjusted to that of the other. Note that a frag sometimes shows in both halves of a loop.

WORK-week-long-hand-PLAY-time-card-case-WORK
COAT-TAIL-back-fire-plow-shoe-horn-TAIL-COAT-rack-work-book-
rest-rain-COAT-TAIL
SONG-BIRD-lime-wood-rock-rose-mary-GOLD-FISH-tail-spin-offs-
cour-sing-SONG-BIRD
HOME-LAND-fall-back-fire-clay-bank-roll-OVER-SEAS-cape-work-
outs-pent-anes-tric-HOME-LAND
COAT-rack-work-hand-play-SUIT-case-work-boat-tail-COAT
HOLY-tide-land-lock-nuts-HELL-fire-side-walk-over-HOLY
HAND-ball-cock-crow-FOOT-slog-wood-shed-HAND
MAID-hood-wink-ling-bird-farm-WIFE-like-wise-head-wind-ward-MAID
SEED-cake-walk-over-shoe-TREE-fish-pole-cats-tick-SEED
COOL-ware-room-some-what-ever-more-over-HEAT-able-gate-post-
mark-down-turn-over-COOL
POOR-will-yard-land-slip-over-RICH-weed-hook-worm-wood-land-POOR

		VIROO		SKEW-BALD	
	ence-inte-grum-bles-buck	shee-pish			PATE
VIOL	INGS-ITES	horn-tail-back-pack-rats		pine-cone	
	OTTA-VINO-SITY	wash-down-turn-over		tole	
			free-zing-anas-arca-dias	PORE	
			over	TEMS	
	bits-talk-able-gate-ward-walk		draw-bars-poop-tang-ence-inte-grum-bles	TASE	
			outs-pent-anes-tric-home-SPUN		
		wood-side-show-ance-rata-plan-gent-LEST-ODON-TOID			
	hawk-moth-worm				
GOSS		root-hold-over-free-zing-anas-arca-dias-pine-cone-PATE			
	AMER-CING-ULUM				
		wood-cock-crow			
	ATRO		bars-poon-tang-ence-inte-grum-gles		
	CITY-ward-walk-over-draw				
	PUTA-MINA				
		nose-wing-back-pace-rats			
	cone				
		ship-side-step-dame			
		gear-case-wood-reed-buck-shee-pish			
	head			bits	
		lock-outs-cold-cock-crow-foot-sore-hawk			
				moth-ERLY	
		land			
		wire-bars-poon-tang-ence-inte-grum-bles			
		fam-land			
	gent-rice-bird	life-hold-over-free-zing-anas-arca-dias-pine-cone-PATE			
		lime-wood-cock-crow-foot-sore-hawk-bits			
		vine-wing		ZOON-OTIC	
dame			over-come-ther-emin-ENTO		
	wort-hier-arch-band-worm-root-hold			DERM	
rats-bane					

APPENDIX B

backfall backfire backkick barabara birdcage birdsong boilover bonefish
 bookcase bookland bookwork bootjack burnover burnside cagebird casebook
 chowchow coattail comedown couscous deerkill dishwash dividivi dovering
 downcome downface downplay downtake downturn facedown fallback fireback
 fishbone fishpond folkland ganggang gandplow greegree handwork hangover
 hardpans headlong headwork hillside holdover hookweed hotshots jackboot
 kavakava kickback kildeer kouskous landbook landfolk lavalava likewise
 longhead mateship overboil overburn overhang overhold overpass overslip
 overtake overturn overwing panshard passover piripiri playdown plowgang
 pondfish ringdove rootworm shipmate shipwork shopwork sideburn sidehill
 slipover songbird tailcoat takedown takeover ticktick turndown turnover
 washdish weedhook wingover wiselike woodworm workbook workhand workhead
 workshop workshop wormroot wormwood

bankweed beanweed bindweed birdweed boleweed bullweed caseweed clayweed
 cockweed coolweed cropweed deerweed doorweed downweed duckweed fireweed
 goldweed hairweed hardweed hawkweed hellweed hookweed ironweed itchweed
 knotweed lakeweed markweed mintweed neckweed pinkweed pokeweed pondweed
 richweed roadweed rockweed sandweed seepweed silkweed snapweed soapweed
 tackweed tickweed toryweed wireweed wiseweed woolweed wormweed

aARd abAS able aces aCId acKS aCre ADes aGEd aGER agES AGly agOS aiLS ALba aLER ally aLUM
 aMan aMen AMId aMOR anal anas ance anes anet anna aNOS ANti antS arca arch arms arOO ARre
 ASpi ATro aTUM aunt aWay back baGS bAIIt bAKE bALd ball band bane bANG bank bara BARd BARE
 bARK BArn BArr bars BART base baSH bass BAST baTe bath baTS BEAd beak beam bean bear beat
 beds bees bell belt bend bent bERy bill bind bird bite bits BITt bles bLET blow bLUe boat
 bODE body boil bold bolt bomb bone book boOM BOon BOOS boot BOrd bore bORN bowl bows boYS
 bras brat bred brew BRoc brow buck buGS BulK BULL bURg burn bURr bURs bush busy cage cake
 cAla call came cANa cANt cape cAPs cARa card cARE cARs cart case cast cATE cATO cats cava
 ceLS cent ceTS CHAr chat cHEe chel cher ches CHIP CHit cHOL chow cite cITy cLAd CLam clap
 clay clic CLod CLog COAL coat cock coDS COen COin cold cole COLi come cone cONS cook cool
 cope COpy COrd COre COrn COse COSt COtE COtS cour cram CRay cREW crib CRis crop crow cUBE
 CUck cuFF cuPS curb dame dAMP dANG dash data date DEAd deal dean deAR DEci deck deem dEEp
 deer dENT dERM dest dias dIct dies dINe dING dish dive divi dOCK does dogs doMS doNE doNG
 dOOm door DOpe DOrs DOSk dove down draw DRib drop duNE dust edge eeDS EEls eLED eMER emIA
 emin ence ency eNDs enED enSe enTO enTS eRAS erLY erOO eTER etTE Even ever eyes face fact
 fall fang fARE farm fast fear feed feEL feET feLT fEND fill fIne fInS fire fish fLAg flap
 fLAt flip flow foIL fold fond fOOD foot fORE form FOrs fort foul Four foWL free frog
 FRom full fuLS GAge gAIIn gall gang gARD Gast gate GAVE gear geES gent gERM gets ghIE giFT
 gild gird girl giSH glad GLee gLEs gLOW goad goat gold gONE goNS good goWN grad gree Grew
 GRid grip grow grub grum guns gUTs hack haDE hAGs hair Half hall hand hang hANK hANS hard
 hARS hate haul HAVE hawk head heAP hear heat HEel heET hell hene heNS herd hERE hERS HETA
 hier hiES high hill HIInd hiNE hIPs hiTE hogs hold hole holy home hone hood hoof hook hoot
 hOPs hORE horn hots hunt husk idES idle iLEs inES inga inOS inte inUM ionS iron isES iTCh
 ITer itES jack JAil jeTS joys jump just KAKE kANG kava KEYS kick kill kind king kins knob
 knot knOW kuLL lace lADA lADE lady laID lamp land lane lANG laNS lark late lava leaf
 leap LEft leRS LESS leST leTS leUR liAR lick LIco liES life lift like lily lIMb lime line
 ling lINs LInt lion list lite live load lock loFT long look lord lORe loTS love lUCK lude
 LUke mAdE maid mAIn make MALa MAMe many mark maRT mary mASS mAST Mata mate meal mEAT Medi
 melt mENs ment meRS miAS mILd mile mILk mill mINa mINe ming Mini mINS mINT mISE MIss mist
 mite mITH mOCK mold Momo MONo moot mops more MORT mOSE Moss most moTE moth muCH mUCK nail
 naLS NAMA nAME nata near neat neck neSS nest neTS nine niNG nite nose note NUMs nuts
 oCCi offs ogES oils onED onES onNE oOTS oper orAL orES OSna otIC OTTA OUGH outs over oWED
 paCE pack page PAIs paLE palm pans pANT pARa PARR pART paSH pass pAST paTE paTH peak pEAR
 pEDE peEL pEEp pens pent PERi PERs pest pIAs pick pied pike pile pINA pine ping pink pins
 pipe piRE piri pish piTA plan play Plea pLEd pLES pLOT plow plug PLUM poke pole POLl POLy
 pond PONY pool poon poor poRE port posh post pots pour prit pROP pull purs puss PUta pUTs
 PYoc QUAn quat quen QUil quin QUis race rack raGE rAGs rail rain rAKE rAMi rams rank rash
 rass rata rate rATi rats rAVE real rEAs reat REde reds reed reen REES REfe REIn reis REla
 rene rent rERE rest reTS rice rich rick ride riED rIFe ring riPE rise riTe rive road roBE
 rock roDE roDS roll roof room root rope rose roys ruck ruff rule rUMs ruPT rust sack safe
 sage saID sail saKE sale salt sANd sARD save saWS sCOT seas seat seed seEN seer sell send
 SEra sere SEro seRS SETs SHAm SHAN shaw shed shee sher ship SHIt shod shoe shop shot show
 shut sick side sing SInk sION sIRE siTE siTY siVE size SKew skin skip slap slid slip slog
 slop slow SLug SLUM sNap soAp sock soft soLe some song soPS sore Sort soul Soup sour span
 SPic spin spit spot sPUN spur STac STAg sTAL STAm star stay sted sTEe stem sTEN step ster
 stir stop stor sUDs suit sure surf sway SWim taCH tack taff taGS tail tain take talk tame
 tang tANK taNS tANT taPS tart taSE task teen teER tELl teMS tENS tent term tERN teRS test
 thea ther thin THou thra tiCe tick tide TiDy tier tile time ting tink tIPs tire tISH tith
 Toad toCK toil tole tONE tool tops toRS tory toss town toWS Tram Tran trap trAY tree
 tres tric trim trip tRUE TRUn trus tube tUNg turn tYpe uile ukES unes unTO uRES uRIC vENT
 VERb vEST view vine vINO VIol vote Wain wAKE walk wall WAlT wAND ward ware wARM waRN warp
 wart wash WAYs weak wear weed week wELd well wENT WERE what when whin WHip WHiz wiCH wier
 wife WILd will wind WIne wing wink wire wise wiTE WITH wOLF wood word work worm wORN wort
 writ xANT yard yest zing zOON