Information Hiding in KWIC

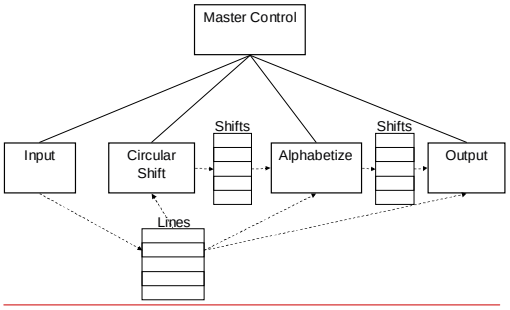
15-413: Introduction to Software Engineering

Jonathan Aldrich

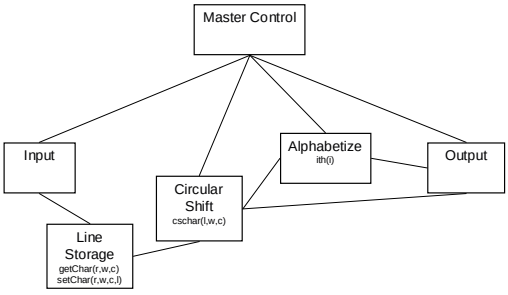
Key Word In Context

- "The KWIC [Key Word In Context] index system accepts an ordered set of lines, each line is an ordered set of words, and each word is an ordered set of characters. Any line may be "circularly shifted" by repeatedly removing the first word and appending it at the end of the line. The KWIC index system outputs a listing of all circular shifts of all lines in alphabetical order."
  - Parnas, 1972

KWIC Modularization #1



KWIC Modularization #2

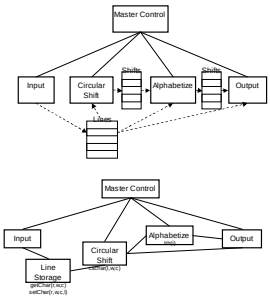


KWIC Observations

- Similar at run time
  - May have identical data representations, algorithms, even compiled code
- Different in code
  - Understanding
  - Documenting
  - Evolving

Effect of Change?

- Change input format
- Don't store all lines in memory at once
- Avoid packing 4 characters to a word
- Store the shifts directly instead of indexing
- Amortize alphabetization over searches



Effect of Change?

- Change input format
  - Input module only
- Don't store all lines in memory at once
  - Design #1: all modules
  - Design #2: Line Storage only
- Avoid packing 4 characters to a word
  - Design #1: all modules
  - Design #2: Line Storage only
- Store the shifts directly instead of indexing
  - Design #1: Circular Shift, Alphabetizer, Output
  - Design #2: Circular Shift only
- Amortize alphabetization over searches
  - Design #1: Alphabetizer, Output, and maybe Master Control
  - Design #2: Alphabetizer only

Other Factors

- Independent Development
  - Data formats (#1) more complex than data access interfaces (#2)
  - Easier to agree on interfaces in #2 because they are more abstract
- Comprehensibility
  - Design of data formats depends on details of each module
  - More difficult to understand each module in isolation

Decomposition Criteria

- Functional decomposition
  - Break down by major processing steps
- Information hiding decomposition
  - Each module is characterized by a design decision it hides from others
  - Interfaces chosen to reveal as little as possible about this

A Note on Performance

- Parnas says that if we are not careful, decomposition #2 will run slower
- He points out that a compiler can replace the function calls with inlined, efficient operations
- This is 1972!
  - But we still hear silly arguments about how (otherwise better) designs are slower
  - Smart compilers enable smart designs

Design Structure Matrices

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Design Structure Matrices

	A	B	C
A	.		
B	X	.	X
C		X	.

Figure 1: DSM for a design of three parameters.

- Goal: to capture dependencies in the structure of a design
- A, B, and C are *design parameters*
  - A choice about some aspect of a design
- X means row depends on column
  - B is *hierarchically dependent* on A
    - If you change A, you might have to change B as well
    - Suggests you should make a decision about A first
  - B and C are *interdependent*
  - C and A are *independent*

Design Structure Matrices

	A	B	C
A	.		
B	X	.	X
C		X	.

Figure 2: DSM for a proto-modular design.

- Lines show clustering into proto-modules
  - Indicates several design decisions will be managed together
- True modules should be independent
  - i.e., no marks outside of its cluster
  - Not true here because B (in the B-C cluster) depends on A

Design Structure Matrices

	I	A	B	C
I	.			
A	X	.		
B	X		.	X
C			X	.

Figure 3: DSM for a modular design obtained by splitting.

- Interface reifies the dependence as a design parameter
  - Instead of B depending on A, now A and B both depend on I
  - Serves to decouple A and B
  - Think of I as the interface of A

KWIC Design #1

KWIC Design #1

	A	D	G	J	B	E	H	K	C	F	I	L	M
A - Input Type	.												
D - Circ Type		.											
G - Alph Type			.										
J - Out Type				.									
B - In Data					.	X	X						
E - Circ Data					X	.	X						
H - Alph Data					X	X	.						
K - Out Data								.					
C - Input Alg	X					X			.				
F - Circ Alg		X			X	X				.			
I - Alph Alg			X		X	X	X				.		
L - Out Alg				X	X			X	X			.	
M - Master	X	X	X		X								.

Interdependence of data formats

Many data dependences

True modules

KWIC Design #2

	N	A	D	G	J	O	P	B	C	E	F	H	I	K	L	M
N - Line Type	.															
A - Input Type		.														
D - Circ Type			.													
G - Alph Type				.												
J - Out Type					.											
O - Line Data	X					.	X									
P - Line Alg	X					X	.									
B - In Data		X						.	X							
C - Input Alg	X	X						X	.							
E - Circ Data	X		X							.	X					
F - Circ Alg	X		X							X	.					
H - Alph Data				X								.	X			
I - Alph Alg				X	X							X	.			
K - Out Data						X								.	X	
L - Out Alg				X	X	X								X	.	
M - Master	X	X	X	X	X											.

Dependence on interfaces

True modules

EDSMs: Considering Possible Changes

- Environment and Design Structure Matrices
  - Sullivan et al., ESEC/FSE 2001
- Add changes as *environmental parameters*
  - *Note: slightly more concrete than what Sullivan et al. propose*
  - Only partially controlled by designer
  - May affect each other
  - May affect design decisions in code
- What interfaces are affected?
  - Information hiding: interfaces should be stable
- What implementations are affected?
  - Information hiding hypothesis: should be local to a module

Effect of Change – Design #1

Effect of Change – Design #1

Interdependence of changes

Unstable data interfaces depend on changes

Algorithms depend on data

	V	W	X	Y	Z	A	D	G	J	B	E	H	K	C	F	I	L	M
V - Input Fmt	.																	
W - Store Mem		.		X	X													
X - Char Pack	X		X	.	X													
Y - Shift Store		X		X	.													
Z - Amortize					.													
A - Input Type						.												
D - Circ Type							.											
G - Alph Type								.										
J - Out Type									.									
B - In Data	X		X								.	X	X					
E - Circ Data				X							X	.	X					
H - Alph Data				X	X						X	X	.					
K - Out Data														.				
C - Input Alg	X	X		X		X					X				.			
F - Circ Alg		X		X	X		X				X	X				.		
I - Alph Alg		X		X	X	X		X			X	X	X				.	
L - Out Alg		X		X	X	X			X	X			X	X				.
M - Master					X		X	X	X									.

Effect of Change – Design #2

Interfaces are stable

Effect of change is localized

	V	W	X	Y	Z	N	A	D	G	J	O	P	B	C	E	F	H	I	K	L	M
V - Input Fmt	.																				
W - Store Mem		.		X	X																
X - Char Pack	X		X	.	X																
Y - Shift Store		X		X	.																
Z - Amortize					.																
N - Line Type						.															
A - Input Type							.														
~~D - Circ Type~~								.													
G - Alph Type									.												
J - Out Type										.											
O - Line Data		X		X		X					.	X									
P - Line Alg		X		X		X					X	.									
B - In Data	X						X						.	X							
C - Input Alg	X					X		X					X	.							
E - Circ Data				X		X		X							.	X					
F - Circ Alg				X		X		X							X	.					
H - Alph Data					X				X								.	X			
I - Alph Alg					X			X	X								X	.			
K - Out Data										X									.	X	
L - Out Alg								X	X	X									X	.	
M - Master						X	X	X	X	X											.

Summary

- EDSMs are a structured way of thinking about the value of design
  - Are design decisions isolated to a module?
  - How do modules depend on interfaces?
  - How are interfaces and code affected by change?