Construct of a Super System for Capture to Output

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Abstract
An exercise in system architecture is demonstrated that considers components and capabilities for a commercial printing workflow from capture to output. Various aspects of this workflow are discussed, including business and production requirements, design elements, process control, available technologies, standards, efficiency, flexibility, and scalability. The discussion reflects upon the changing environment for commercial printing, which has been going through a digital transformation and depends heavily on technology.

Introduction
In recent years, several significant and interrelated trends have been observed in the commercial print industry. A few of such trends include:

- the continued and somewhat accelerated process of digital transformation for the industry, as marked by growing adoption of digital printing for new applications, such as personalized printing and print on demand, and by ancillary distribution of print content via worldwide web. Both examples highlight the need for multi-purposing of digital assets.
- the broad use of digital assets with increasing use of digitally automated workflows for the purpose of realizing higher cost efficiencies.
- a pronounced effort to closely manage business processes alongside that of production processes.

These trends create the dynamics of change and chaos. They introduce a challenge for operations; a challenge to design a production workflow that efficiently accommodates both conventional printing as well as digital printing, one that is tightly coupled with enterprise resource planning and business performance measurement systems. If viewed as a super system, basic system architecture principles may be applied to complete this design.

System Architecture
One of the basic principles of system architecture is the process of decomposition and partitioning. The process involves decomposing and listing all elements of the desired super system. Once decomposed, the elements are rearranged and partitioned into new systems and subsystems to achieve an optimum design.

Design structure matrix (DSM) may be used as a technique to help with the process of decomposition and partitioning.

In the following pages, this process is followed and a design is presented. This design may be customized by the reader for a more specific list of decomposed system elements.

Decomposition
Listed in Figure 1 is the decomposed set of system elements under consideration. These elements represent generic operations for production and business management. Production operations range from capture and creation of digital elements (e.g., digital images and illustrations) to output, in terms of conventional print (e.g., offset or gravure) and digital print (e.g., short-run print-on-demand). In between, a number of relevant operations are included, such as page assembly for both static and variable data, various proofing operations, imposition, trapping, data management, asset management, and process control. Also included are business operations including job estimation, ordering and planning, job data collection and analysis, billing and accounting, and business improvement processes.

Partitioning
As illustrated in Figure 1, a design structure matrix is used to capture all interdependencies among these operations. Operations are labeled in 36 rows from "A" to "AJ," and mirrored in 36 columns again from "A" to "AJ." The diagonal separation marks the intersection of the same elements. An entry in any cell shows the dependency of the operation in the row of that cell on the operation in the column of that cell. For example, there is an entry in the cell where row "D" intersects with column "C," and it signifies that Job Planning (D) depends on Job Specification (C).

Cells below the diagonal show dependency of one operation following another operation; whereas, cells above the diagonal show feedback from a future operation.

One of the goals of partitioning is to rearrange the order of the operations such that dependencies are reduced to a minimum. Another goal is to identify operations that might be eliminated or grouped into higher-level decompositions. Figure 1 shows the result of this process after several attempts in partitioning. Simplicity that might be observed by the reader demonstrates the goal of this process. At the start of the process, decomposition was performed at a lower level, to include operations and technologies such as RIP and halftone screening as well as standards, such as PDF and JDF. Through this process, these elements were eliminated and/or collapsed into higher-level operations in order to achieve simplicity. RIP and halftone screening are considered to be possible functioning components of making proofs and plates. Additionally, although important, standards such as PDF and JDF are general choices made for the overall production workflow, and, as such, they were regarded as prerequisites for the system and thus eliminated from consideration.

The only feedbacks that remain are related to:

Items		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
Calibrate Output Devices	A	A																																			
Job Estimating / Pricing	B		B																									0									
Job Specification and Ordering / Re-spec / Author s Alteration	C		0	C						0						0			0		0						0										
Job Planning	D			0	D					0																								0			
Capture / Create Digital Element (Image, Illustration, etc.)	E				0	E				0																											
Convert Digital Element for File Format and/or Color Space	F				0	0	F																														
Retouch and Color Correct Digital Element	G				0	0	0	G		0																											
Color Control for Output Devices	H	0			0				H	0																											
Proof Digital Element	I	0			0	0	0	0	0	I																											
Assemble / Compose a Static Page	J				0	0	0			0	J					0			0		0																
Assemble / Compose a Variable Data Page	K				0	0	0			0		K				0			0								0										
Convert Page for File Format and/or Color	L				0						0	0	L																								
Edit Page	M				0						0	0	0	M	0	0																					
Color Manage Page	N				0						0	0	0		N	0																					
Proof Page	O	0			0				0		0	0	0	0	0	O																					
Add Metadata	P				0	0					0	0					P																				
Impose	Q				0						0	0	0	0				Q	0		0																
Proof Imposed Pages	R				0													0	R																		
Trap	S				0						0	0	0	0	0					S	0																
Make Contarct Proof	T				0															0	T																
Make Plates	U				0													0		0	0	U															
Print using Conventional Methods	V				0						0							0			0	0	V														
Data Mine and Cleanse	W				0																			W													
Postal Pre-Sort	X				0																			0	X												
Merge Personalized Data	Y				0							0												0	0	Y											
Print using Digital Print Methods	Z				0							0						0		0						0	Z										
MIS Data Collection	AA	0				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AA									
Utilization Analysis	AB					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AB								
Resource Usage and Accounts Payable	AC																											0	0	AC							
Billing	AD		0	0																			0				0				AD						
Accounts Receivable	AE																														0	AE					
ROI and Job Costing Analysis	AF																											0	0	0	0	0	AF				
Resource Investment and Allocation	AG																											0	0				0	AG			
Analyze Output Devices for Process Control	AH									0						0					0	0	0				0								AH		
Archive Assets	AI					0	0	0			0	0	0	0	0		0							0	0											AI	
Archive Resources (Profiles, Fonts, etc.)	AJ							0	0		0	0	0		0			0																		0	AJ

Figure 1. Design Structure Matrix

1. **Proofing:** Every proof creates the potential for a corrective cycle. For example, a proof of a digital image might result in rework of the image or a change in the specification of the job.
2. **Digital Print:** Essentially, a digital print serves as its own proof, and it might result in rework or a change in the specification of the job.
3. **MIS Data Collection:** Past performance (cost of labor, materials, etc.) might impact future job estimates.
4. **Resource Investment and Allocation:** Decision in resource planning might impact job planning.

All of these feedbacks are considered to be important for the robustness of the design.

Subsystem Identification

Outlined sections in Figure 1 signify subsystems that may be separated. For this process, eight subsystems have been identified. These include (from top to bottom) a capture and create subsystem, a page assembly subsystem, an imposition subsystem, a contract proof subsystem, a conventional print subsystem, a digital print subsystem, an MIS data collection and analysis subsystem, and a billing and accounting subsystem.

Most of these subsystems are marked by the fact that they provide feedback. However, feedback was not a condition for subsystem identification. The process of identifying the subsystems is more of an intuitive process.

System Architecture Realized

Figure 2 shows rearrangement of the identified subsystems into a final system architecture. Several notable observations should be made here, as follows:

1. Arrows show the sequential nature of these operations as well as their interdependencies, both of which are highly important elements of the design and may be used as the basis for automation.
2. The scope of the decomposition and partitioning process used earlier ended with print. However, Figure 2 includes the step of finishing and fulfillment after print. Addition of this step was not arbitrary; rather, it was necessary to trigger billing. It demonstrates the flexibility of the process as it was added with no consequence to the decomposition and partitioning process.
3. There is a common production thread that is leveraged for both conventional and digital printing. This thread includes job estimation, job specification, job planning, capture and create, imposition, archival, and finishing and fulfillment. Also in common are billing, MIS data collection, and ROI analysis. These common operations signify critical paths that exist in the system.
4. Branching out of capture and create into separate paths for conventional and digital print demonstrates the ability of the system to allow multi-purposing of the digital assets.
5. This design is easily scalable because it allows for further multi-purposing, if necessary. For example, another branch may be added out of capture and create to accommodate web publishing as a parallel path to conventional and digital print paths.
6. In this design, the production workflow (i.e., capture and create followed by imposition and printing) is tightly coupled with business management processes (i.e., job management, MIS data collection, billing, and ROI analysis)

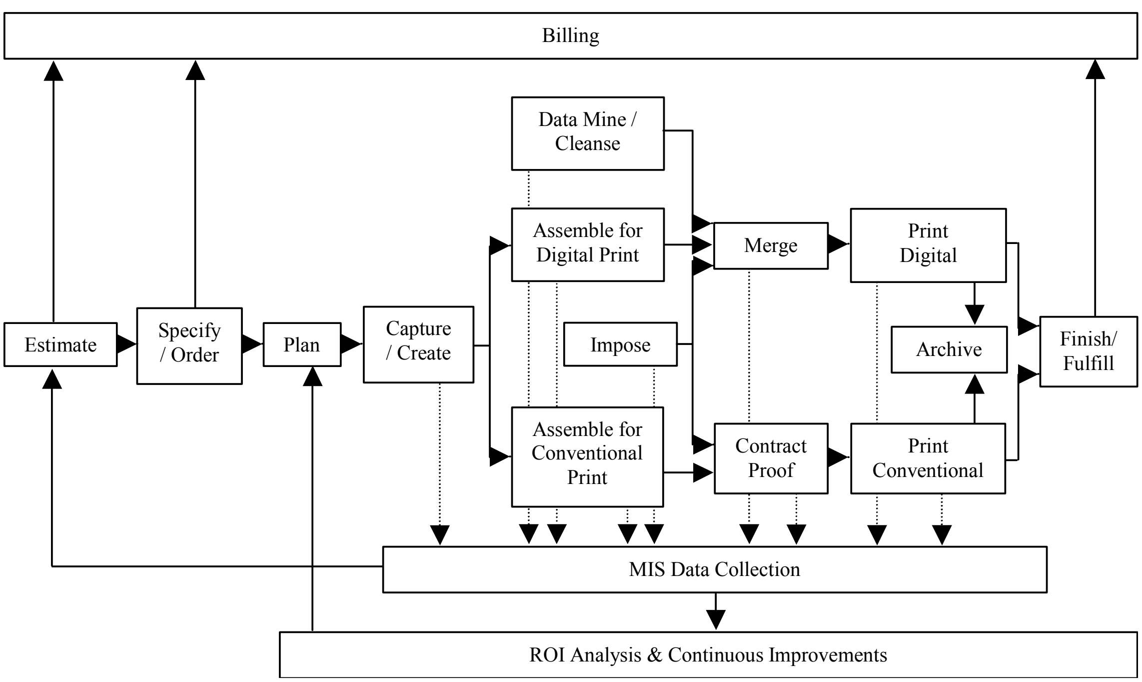

Figure 2. A Super System for Capture to Output

Conclusion

System architecture principles and tools were used to design a workflow super-system that meets the growing needs of commercial printers. Specifically, this super system is designed to handle multi-purposing of digital assets for conventional and digital printing methods; its production workflow is tightly coupled with business and enterprise management processes; and it is streamlined for automation. Finally, its critical paths are obvious.

References

For more information about Design Structure Matrix (DSM), decomposition, and partitioning techniques, and for links to related publications refer to http://www.dsmweb.org/index.html

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Nader Anvari holds a Master of Science Degree in Engineering and Management from MIT/Sloan School of Management (1999) and a Master of Science Degree in Electrical Engineering from IIT (1984). Since 1985, he has worked for Eastman Kodak Company. In his current role as System Architect with the Graphic Communications Group at Kodak, he helps develop new product concepts based on new market trends and technologies. He represents Kodak on the Committee for Graphic Arts Technologies Standards (CGATS), Subcommittee 6, Task Force 1 for PDF/X standards. Nader is on the Board of Directors for the Center for Change in Rochester, New York.