Pugh Matrices

Embedded Interface Design

with **Bruce Montgomery**

Exam Review

- Before we start, let's take a walk through the midterm…

Learning Objectives

- Students will be able to…
  - Understand and apply Set-based Pugh matrices to make design decisions based on group criteria assessments

Protocol Assessment

- You're designing an IoT style application…
- People on the team know MQTT, AMQP, XMPP, CoAP, and WebSockets
- The customer hasn't specified a IoT Application Protocol (and doesn't know how to)
- What do you do?
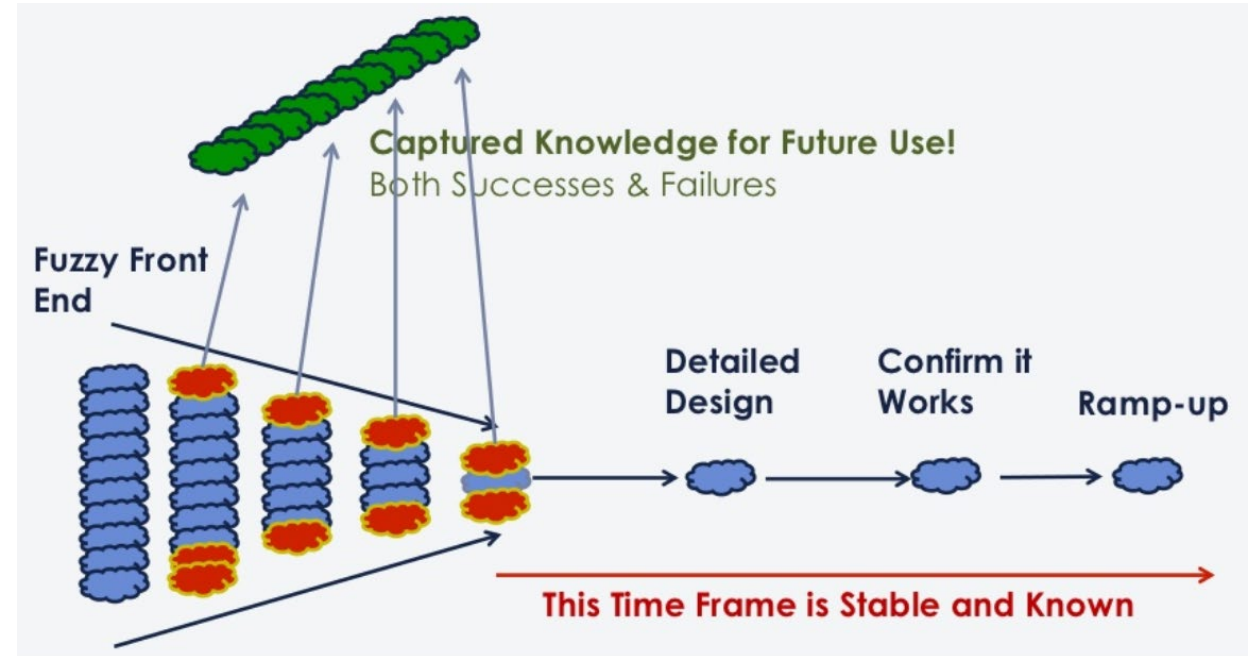
Possible criteria for selection...

- Proprietary vs Interoperable
- Message Size
- Latency
- Power for Processor Time
- Messaging: Pub/Sub, Req/Resp, Broadcast, etc.
- Known Strengths/Weaknesses
- Adjacent & Similar Networks - Separating Us from Them
- Availability of tools
- Vendor/Source
- Cost/Licensing/Royalties
- Where Used Today
- Certifications
- Frequency/Bandwidth Use – Spread Spectrum/Spectrum Use, Regulated/Unregulated

- Stage of lifecycle/Age of protocol
- Network Traffic (Messages/Sec, timing between messages)
- Time Sync for Communication/Power Control
- Node Density/Endpoint limits/Scalability
- Topology/Network Architecture: Tree, Star, Mesh, etc.
- Power Use/Battery Life (Energy/Bit?)
- Range
- Data Rate
- Immunity to Interference
- Location Support
- Propagation/multi-pathing concerns/collision detection

- International use
- Message Order
- Packet Prioritization (as for voice)
- Retransmissions/Retries
- Security (AAA, Encryption) – Hackable, Discoverable
- Signing
- Message ID
- Error Correction/Detection
- Data Compression
- Optimization/Adaptive – data rates/power use
- Chip support

Can you balance all this?
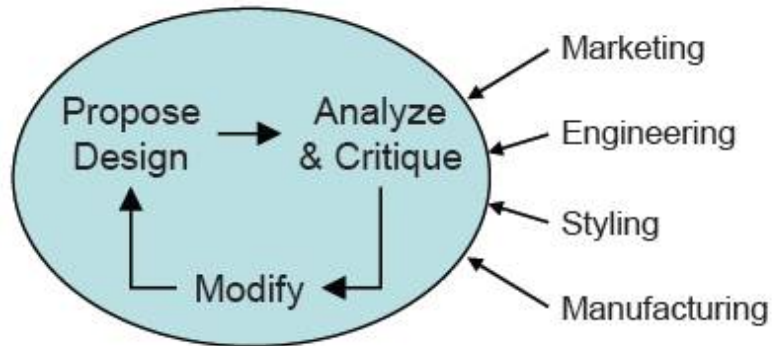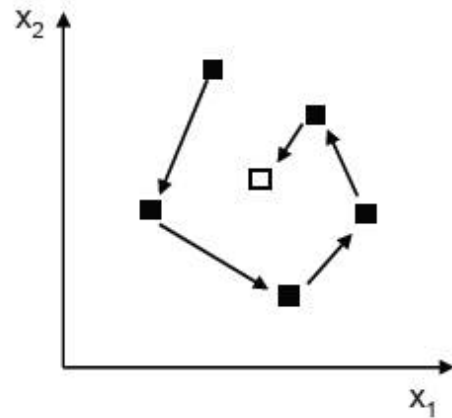
University of Colorado **Boulder**

Set-based Design

- Set based design involves exploring many design alternatives up-front to allow for trade-offs
- particularly important for integrated systems with competing requirements
- In Lean development, you want to delay design decisions to achieve optimal trade-offs by eliminating inferior alternatives
- This means front-end loading of learning, identifying risks and mitigation, and assessing alternatives
- Avoid moving toward "favorite" solutions
- Reference [1]

Captured Knowledge for Future Use!
Both Successes & Failures

Fuzzy Front End

Detailed Design

Confirm it Works

Ramp-up

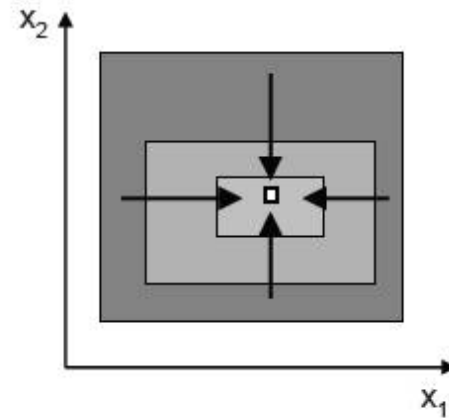This Time Frame is Stable and Known

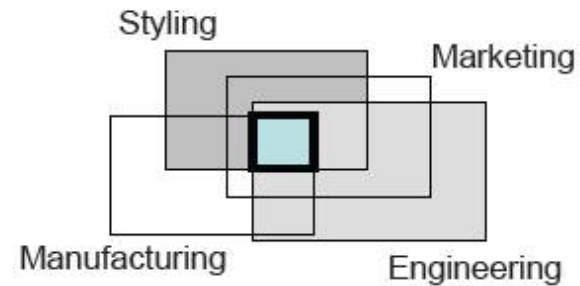# Point-based Design vs. Set-based Design

"Point-based" Design

Set-based Design

Eliminate Dominated Alternatives

Reference [2]

Pugh Matrix

- A lean/six-sigma tool also known as a criteria-based matrix
- Identify current baseline (if available) and key selection criteria
- Example: buying a car [3]

Selection Criteria	Baseline – Current Car	Solutions		
		Car A	Car B	Car C
Fuel system	0	-2	2	-1
Four-door	0	2	2	-2
Miles per gallon	0	2	2	0
Sound system	0	1	2	-1
Warranty plan	0	0	2	-1

Pugh Matrix Process/Template

Pugh Matrix Process

Assemble the team → Enter current baseline design → List optional concepts → List key design criterion → Determine criterion weight → Rank concepts (+1, 0, -1) → Sum the scores for each concept → Select best concept

Reference [4]

Pugh Matrix

VALUE GENERATION PARTNERS

Project Name:

Project Manager:

Date:

Key Criteria	Baseline	Concept 1	Concept 2	Concept 3	Concept 4	Weight
Criterion 1	0					
Criterion 2	0					
Criterion 3	0					
Criterion 4	0					
Criterion 5	0					
Criterion 6	0					
Sum of Positives (+)	0					
Sum of Negatives (-)	0					
Overall Total	0	0	0	0	0	
Weighted Total	0	0	0	0	0	

Pugh Matrix for Protocol Selection

- If currently using a protocol, compare against it
- If not, choose one as a baseline
- List all the possible protocol options you're considering
- List the key design criteria
- Weight those criteria (1-N, 1-5, etc.)
- Score the possible options vs. the baseline (1/3/9, -1/0/1, etc.)
- Look at the results
- Again, caution not to weight favorite choices unfairly
- Reference [4]

VALUE GENERATION PARTNERS   **Pugh Matrix**

Project Name:

Project Manager:

Date:

Key Criteria		Concepts					Weight
	Baseline	Concept 1	Concept 2	Concept 3	Concept 4		
Criterion 1	0						
Criterion 2	0						
Criterion 3	0						
Criterion 4	0						
Criterion 5	0						
Criterion 6	0						
Sum of Positives (+)	0						
Sum of Negatives (-)	0						
Overall Total	0	0	0	0	0		
Weighted Total	0	0	0	0	0		

References

[1] https://www.slideshare.net/AGILEMinds/michael-kennedy-setbased-decision-making-taming-system-complexity

[2] https://alopexoninnovation.files.wordpress.com/2013/06/set-based-design.jpg

[3] https://www.isixsigma.com/featured/resource-page-pugh-matrix

[4] https://www.linkedin.com/pulse/generating-value-using-pugh-matrix-rod-baxter