BCS Edinburgh Branch

Delivering mission critical systems

Colin Butcher CEng FBCS CITP

Technical director, XDelta Limited

www.xdelta.co.uk

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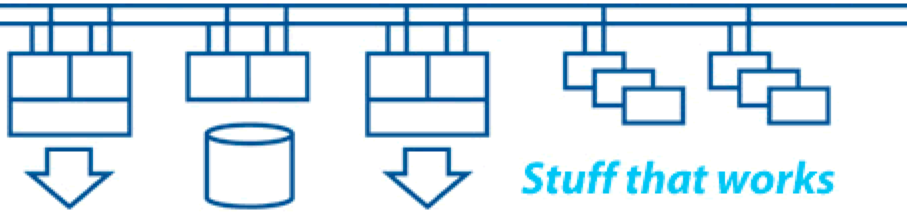

Agenda

Introduction
Systems engineering – design principles
Availability and performance
Risk and failure analysis
Testing, transition and operation
Project planning and management
Leadership and people
Summary

Personal background

- Systems architect specialising in mission critical systems
- Engineering background
- Wide range of experience (satellite flight control, air traffic monitoring, finance data, healthcare, etc.)
- Started XDelta in 1996

XDelta – what we do

- Lead mission-critical systems projects
- Deliver world class services in demanding environments
- Strategic planning, technical leadership and project direction with clarity of vision and an eye for detail
- Systems engineering for availability and performance
- Ensure long term success through skills transfer

What are mission-critical systems ?

Systems that are relied on to get something done, without data loss or corruption and without stopping working when they need to work.

Usually there is some kind of severe penalty for systems failure, be it financial, or legal, or business-threatening, or life-threatening.

Terminology

- Availability:
    - Probability of system being available for use when needed
    - Function of MTBF (reliability) and MTTR (repair time)
- Disaster tolerance:
    - Surviving major site outages without loss of service
- High availability:
    - Surviving failures at a site without loss of service
- Disaster recovery:
    - Restarting systems after loss of service, typically from another location (DR site)

Mission critical system characteristics

- Mission critical systems need to be able to:
  - Survive failures (resilience and failover)
  - Survive changes (adapt and evolve)
  - Survive people (simplify and automate)
  - Never corrupt or lose critical data (data integrity)

- What is the “operational window” ?
- Safety-critical systems also have to be “fail-safe”
- Real-time systems also have precise performance targets

Mission critical system examples

- Telephony and communications
- Power generation and distribution
- Air traffic monitoring and control
- Railway signalling
- Traffic flow control (cities, motorways, etc.)
- Healthcare (logistics, blood, x-ray, administration, etc.)
- Stock exchanges and finance data
- E-mail services
- On-line shopping
- Your personal laptop

Some important challenges

- We must preserve our data

- We're trying to reduce the probability of failure
- We're trying to minimise the extent of a failure
- We need to understand how and why systems fail
- We need to understand what failure looks like

- We need to get everyone involved, not just specialists

"Survivability test"

Cause of Outage	Planned (Maintenance)	Unplanned (Failure)
Hardware	?	?
Operating System	?	?
Network	?	?
Application Software	?	?
Data	?	?
Environment	?	?
People	?	?

System failures – how are you affected ?

- How do you cater for failures ?
  - What level of outage is acceptable ?
  - What level of data loss is acceptable ?

- How do you set expectations of what’s possible ?

The closer you get to 100% uptime the harder and more expensive it is.

Systems engineering

It's a multi-disciplinary and holistic approach to creating something to meet a specific purpose.

From the NASA Systems Engineering Handbook, June 1995:

"[Systems engineering] is a field that draws from many engineering disciplines and other intellectual domains. The boundaries are not always clear, and there are many interesting intellectual offshoots."

Stages in the life and death of a system

- Requirements
- Design
- Implementation
- Test
- Regulatory approval
- Transition into service
- Operation and support
- End-of-life and transition out of service

It is by no means a smooth and linear progression from stage to stage.

Requirements – it all starts here

- Do not over-specify!
    - 99.999% = 5 minutes per year (24x365)
    - 99.99% = 52 minutes per year (24x365)
    - 99.9% = 8 hours 46 minutes per year (24x365)
- Understand the problems you're trying to solve
- Minimise complexity
- What are the acceptance criteria ?
- Clarity is essential

Be prepared to reconsider if you don't like the price or the timescales – but know what compromises you can safely make.

The design process

- Understand the requirements
- Start with the “ideal design”
- Understand any constraints you have to deal with
- Think ahead to minimise problems later
- Build the whole system “on paper”
- Have a well-structured overall architecture
- Understand the details, complexities and interactions
- Remain flexible and adapt to change

Design decisions

- All design decisions are compromises and require you to exercise judgement
  - Big decisions which have long-term implications and constraints
  - Small decisions which seem big at the time
  - There will be requirements and constraints you don't yet understand or know about
- Make careful assumptions as needed to get started
- Establish meaningful naming conventions
- Document your design and decisions

Problem solving concepts - TRIZ

	Before	Now	After
Environment			
System		■	
Component			

See www.triz.co.uk (and several others) for a lot more information!

"теория решения изобретательских задач"
Teoriya Resheniya Izobretatelskikh Zadach"
"Theory of inventive problem solving"

Availability and performance

A system that doesn't meet its performance requirements is a system that's not working properly, so it becomes unavailable.

Performance related failures are often transient and exceedingly difficult to fully understand and resolve. The systems have to have sufficient capacity and performance to deal with the workload in an acceptable period of time under normal, failure and recovery conditions.

What is "fast" and "slow" ?

- Bandwidth – determines throughput
  - It's not just "speed", it's "units of stuff per second"

- Latency – determines response time
  - Determines how much data is in transit
  - "data in transit" is at risk if there is a failure

- "div latency" (variation of latency with respect to time) or "jitter" - determines predictability of response
  - Important for establishing timeout values
  - Latency fluctuations will cause system failures under peak load

Current technology trends - parallelism

- Move from low core count, high clock rate processors to high core count, low clock rate processors
- Implicit assumption is that parallelism can be achieved
- How does our workload break down into parallel streams of execution ?
- Serialisation, synchronisation and intercommunication

Capacity and scalability

- Contention and saturation – running out of capacity
  - Queuing theory
  - What else are we sharing our capacity with ?

- Increasing the capacity of the overall system:
  - “Scale up” or “vertical scaling” – adding resources to a machine or buying a bigger machine (CPU count, memory, I/O adapters, etc.)
  - “Scale out” or “horizontal scaling” - adding more machines

Designing for performance

- Size systems to cope with peaks in workload

- Minimise “wait states” (caches, parallelism)
  - Don’t make it go faster, stop it going slower
- Maximise “user mode”, minimise the other modes:
  - The fastest code is the code you don’t execute
- Maximise “IO throughput”:
  - The fastest IO is the IO you don’t do

Designing and writing very good code requires very good programmers.

Designing for availability

- Which parts of the system are mission-critical ?
- Which parts of the system are safety-critical ?
- What kind of failure do we prefer ?
- What state transitions occur ?
- Build in the ability to make changes when in service
- Protect the data
- Build “proof of concept” systems and simulators

Risk and failure analysis

Risk is a combination of probability of occurrence and worst-case effects for a given failure scenario.

Allow for failure – success is only one of many possible outcomes.

The risk continuum

- What is the probability of a situation occurring ?
- What is the impact if that situation occurs ?
- What are the long-term consequences ?

- Most projects handle medium risk well enough
- Many projects over-specify to cater for low risk issues
- Some projects under-specify and fail to cater for high risk issues

- We need to identify critical components / people
- We need to identify critical stages during the project

Risk identification and assessment

- Can we identify specific scenarios of interest ?
- Can we test all the conditions ?
- What happens to our data ?

- How can we start to identify what the risks might be ?
- How can we look for single points of failure ?
- How can we look for modes of failure ?
- How can we analyse how failures will ripple through ?

Stuff that works

Testing, transition and operation

A mission-critical system hardly ever fails, so we need the people responsible for its operation to have a good understanding and ‘feel’ for the way it works.

Failure and recovery

- We need to know how the system behaves
- We need to know the ‘warning signs’ of incipient failure
- We need to know how to return the system to its normal operational state without data loss or data corruption

- We need to regularly rehearse and test our procedures and plans to ensure that we stay current

- We must have a representative offline test environment

Testing

- Understand the requirements and acceptance criteria
- How do we generate a typical workload ?
- How do we generate representative data sets ?

- Test under normal, failure and recovery conditions
- Don’t just confirm that the system behaves as expected
- Must test for scalability as well as functionality

Transition into service / out of service

- Minimise risk of data loss
- Minimise risk of loss of service
- Migrate user connectivity
- Migrate live data + historic data

- How can we split transition into manageable steps ?
- Is anything a one-way step ?
- How much can we do in advance ?
- How could we revert to the original system ?

Finding and fixing problems

- How can we spot a problem early on, eg: data corruption ?
- What evidence can we look at ?
- Can we recreate the problem in a test environment ?

- Time synchronisation across the whole system is essential

- Continual monitoring and event logging is essential

- Knowledge of the whole system is essential

Project planning and management

Some useful adages:

“Proper Planning and Preparation Prevents Piss Poor Performance”

“Time spent in reconnaissance is never wasted”

“No plan survives first contact with the enemy”

Planning and implementation

- Estimating and planning are key
- You cannot know everything up front
- Make effective assumptions to get started
- Beware assuming that everything will go well
    - o Cumulative discrepancies add up very quickly
- How will you monitor progress ?
- Checklists are essential, especially under pressure

“More software projects have gone awry for lack of calendar time than all other causes combined.”

“The mythical man-month” – Brooks

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Stuff that works

Management

- Concentrate on quality of information and decision making
- Be thoughtful, not reactive - do not rush to respond
- Regular briefings, in person, phones off, no e-mail
- Need people to be committed
- Never have one person working on their own
- Good administrative support lets people focus on their work

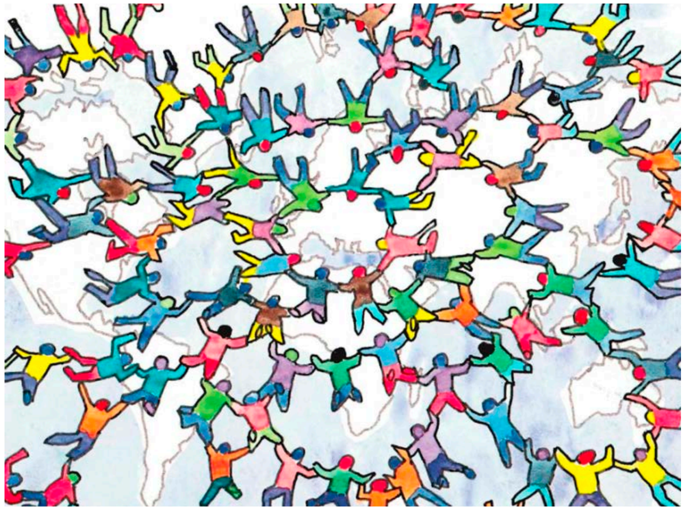
Leadership and people

"Never tell people how to do things. Tell them what to do and they will surprise you with their ingenuity."
General George Patton

"The best executive is the one who has sense enough to pick good people to do what he wants done, and self-restraint enough to keep from meddling with them while they do it."
Theodore Roosevelt

People and behaviours

- Build groups of excellent people who work well together
- Choose people who are willing to share information and help each other
- Give them the support and help they need so that they aren't distracted by trivia
- Confidence good; arrogance bad
- We're all in this together!



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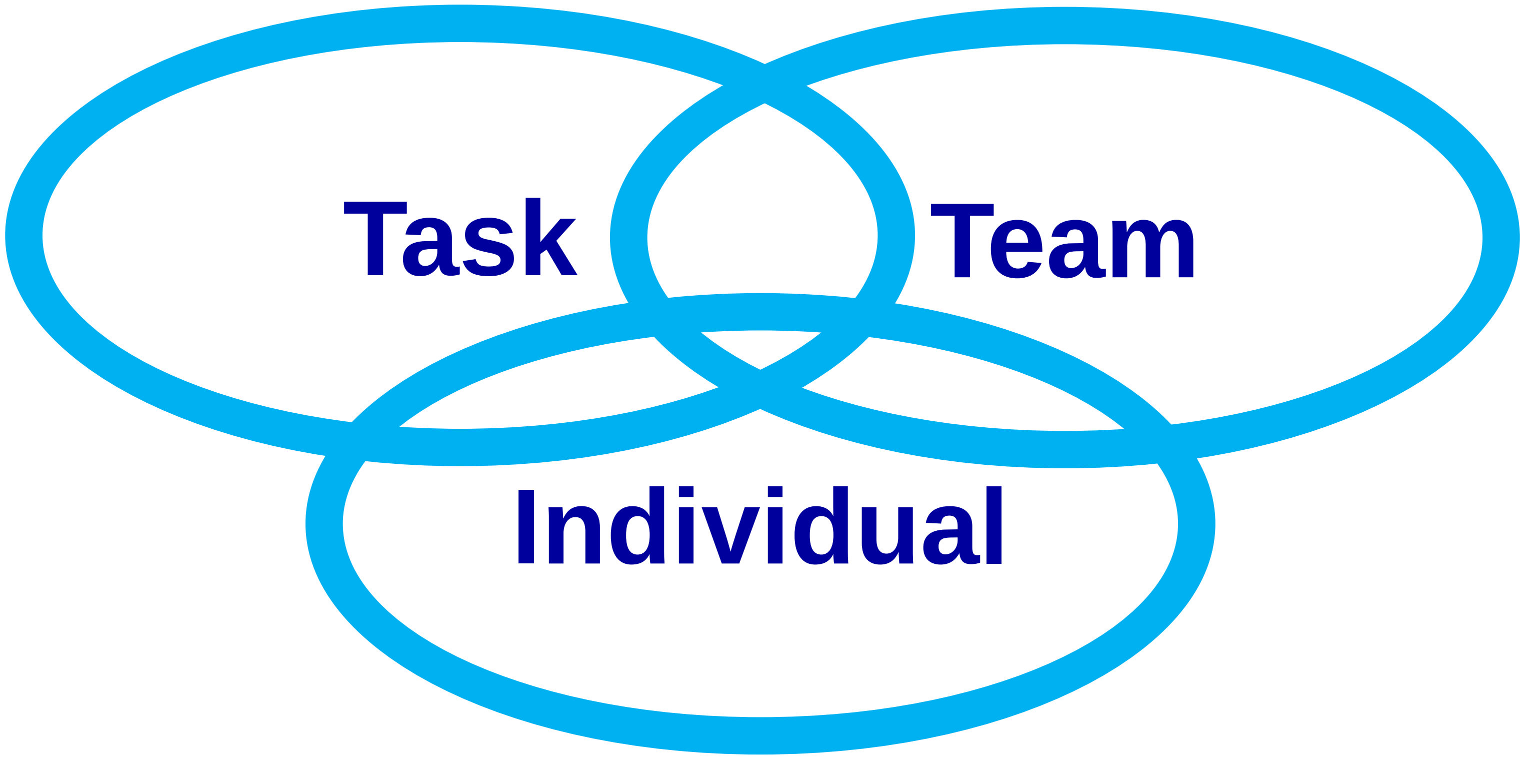
Stuff that works

Action centred leadership – John Adair



See www.johnadair.co.uk for a lot more information!

Action centred leadership – John Adair

John Adair - 6 core functions of Action Centred Leadership model:

1. **Planning** – seeking information, defining tasks, setting aims
2. **Initiating** – briefing, task allocation, setting standards
3. **Controlling** – maintaining standards, progress, ongoing decision-making
4. **Supporting** – individuals' contributions, encouraging, team spirit, reconciling, morale
5. **Informing** – clarifying tasks and plans, updating, receiving feedback and interpreting
6. **Evaluating** – feasibility of ideas, performance, self assessment

Leadership - communication

- First get the ideas clear in your head
- Use the right language for the recipient(s)
- Talk it through collectively
- Give clear details in a workable format
- Make sure your message has been understood as you intended

"Without the right words, used in the right way, it is unlikely that the right actions will ever occur."

Eccles, R.G. & N. Nohria. - Beyond the Hype

Summary

Procurement and responsibility

- Procurement – do enough work up front:
  - Understand what is technically feasible
  - Understand what is strictly necessary
  - Clearly establish the scope
  - Define clear objectives
  - Define acceptance criteria

- Avoid split responsibility and be absolutely clear where the "duty of care" lies

Design, Leadership and Management

- Design and implementation:
  - Have clear objectives. Think ahead as far as you can. Have a well-structured systems architecture. Understand the constraints. Focus on the core functions. Implement them as well as is possible.
- Project leadership:
  - Ensure that everyone involved maintains a consistent understanding of the project. Plan ahead as best you can.
- Budget and Schedule:
  - They have to be appropriate for the problems you're trying to deal with. Don't set them first!

Key success factors

- Strong team of good people
- Collaboration and willingness to share information
- Build a “proof of concept” early on and learn from it
- Minimise complexity
- Structured design
- Clearly defined interfaces
- Document your decisions (what, how, why)
- Make life as easy as you can for those who come after you

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Thank you for your participation

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