Computer Science
UNIVERSITY OF TORONTO

lecture 21
effort estimation

csc302h

winter 2014

recap from last time

- rigorously defined the capacity constraint
  - ***F = N × T***
  - calculated post-facto
- defined what is accounted for by work factor
- need time tracking system that can track:
  - $h_{i,k,d}$ – hours spent by i^{th} developer, on k^{th} feature on d^{th} day of the plan
- in planning, need to estimate F, and N × T and commit to (and track) a plan such that:
  - ***estimated F*** **≤** **estimated (*N × T*)**

estimates

- estimates are never 100% certain
- ex. we may estimate a feature to be 20 ECDs (ideal 8-hour developer days)
  - are we saying it will be done in 20 ECDs? no.
  - so, then what exactly are we saying?
    - is it optimistic?
    - pessimistic?
    - how confident are we in it?
- a quantity whose value depends upon unknowns (or randomness) is called a *stochastic variable* - our plan is full of these!

estimation techniques

Source: Adapted from van Vliet, 1999, section 7.3.5

- function points

  $$\mathbf{FP = a_1 I + a_2 O + a_3 E + a_4 L + a_5 F}$$

  the a_is are "weighting factors"

  I = number of user inputs (data entry)

  O = number of user outputs (reports, screens, error msgs)

  E = number of user queries

  L = number of files

  F = number of external interface (other devices, systems)

- an example might be:

  $$\mathbf{FP = 4I + 5O + 4E + 10L + 7F}$$

estimation techniques (2)

- three-point estimating
  - tends to provide better estimate than asking for a range

    w = worst-case estimate

    m = most likely estimate

    b = best-case estimate

$$E = \sum_i \frac{w_i + 4m_i + b_i}{6}$$

confidence intervals

- toss a coin 5000 times
  - expect heads about half the time (2500)
  - exactly 2500? only about 1.1%
  - ≤ 2500? chance is 50%, on repeated experiments, half will be ≤ 2500, half will be > 2500
  - ≤ 2530? chance is now about 80%
  - ≤ 2550? chance is now about 92%

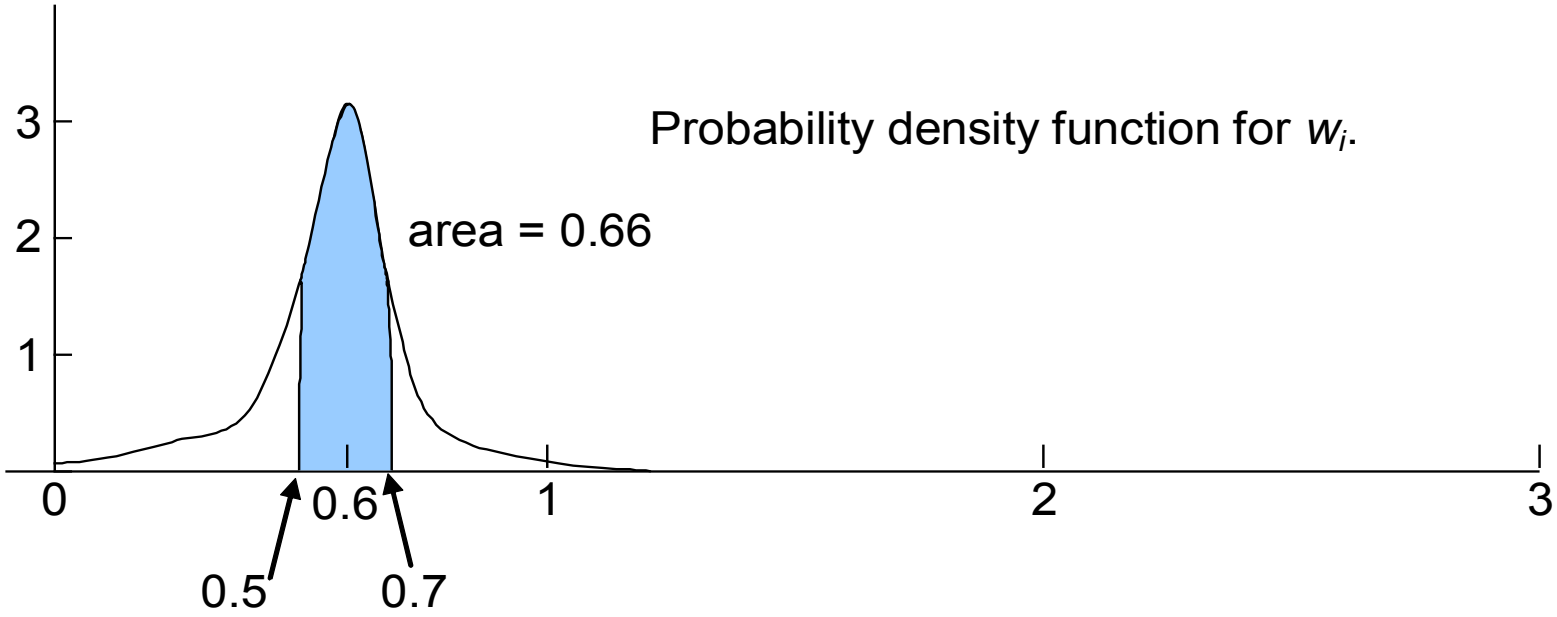
- these (50%, 80%, 92%) are called confidence intervals
  - with 80% confidence we can say that the number of heads will be less than 2530

stochastic variables

- consider a developer with a work factor, *w*
  - *w* (even measured) is a stochastic variable
  - stochastic variables are described by statistical distributions
  - a statistical distribution will tell you:
    - for any range of *w,* the probability of *w* being within that range
  - can be described completely with a probability density function (PDF)
    - x-axis: possible range of the variable
    - y-axis: numbers (density) ≥ 0
    - probability the value is between two values, a and b, is the area under the PDF between a and b

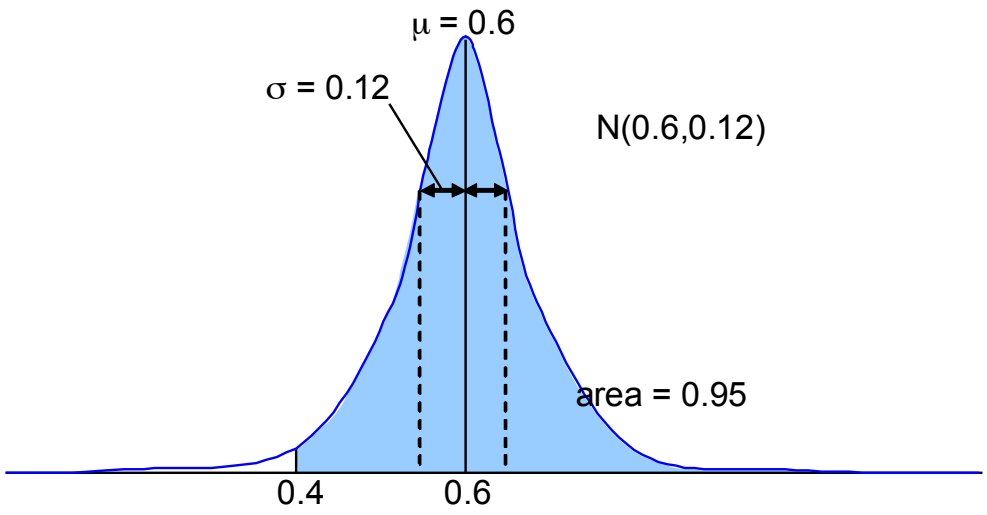
PDF for work factor

- probability that $0.5 < w < 0.7 = 66\%$
- looks to be fairly accurate in practice
  - finite probability of being 0
  - not much chance of being bigger than 1.2 or so



normal for work factor

- assume work factor is described by a normal distribution
- 2-points needed to fit a normal, average case, and some reasonable "worst case"
  - avg. case, half the time less, half more = 0.6
  - "worst" case: 95% of the time w won't be that bad = 0.4
    - normal that fits is N(0.6, 0.12)



back to estimation

- ex. for a feature estimate of 1 week
  - post-facto
    - what are the units?
    - 40 hrs? longer? shorter? dedicated? disrupted (calendar)? one developer? two?
  - stochastic
    - 1 week best case?
    - 1 week worst case?
    - 1 week average case?
    - need a PDF
- depending on these concerns, my “1 week” may be someone else’s 4 weeks!

stochastic capacity constraint

- T is fixed
- F and N are both stochastic variables
- can only speak about the chance of all the features fitting in the release or sprint
- say F = 400, N = 10, and T = 40, are we good to go?
  - can't say for sure
  - need precise distributions for F and N to answer, and then, only with some confidence interval

summing distributions

- F and N are sums over many contributing stochastic variables.
  - ex. $F = f_1 + f_2$
  - if f_1 and f_2 have associated statistical distributions, what is the distribution of F?
    - in general case, no answer
  - if f_1 and f_2 are both normal, then
    - F is also normal
    - mean of F is sum of means of f_1 and f_2
    - standard deviation of F is the square root of the sums of the squares of the standard deviations of f_1 and f_2

law of large numbers

- if we sum lots and lots of stochastic variables, the sum will approach a normal distribution
- therefore, something like F is going to be pretty close to normal
  - ex. dozens of feature estimates summed up
- N will also be close to normal, but probably less so
  - ex. 5 developer's work factors summed up

delta statistic

- $D(T) = N \times T - F$
- we have normal approximations for N and F and can compute the normal curve for D as a function of various values for T.
- we are interested in $P(D(T) \geq 0)$
  - the probability all features will be finished on time
- in choosing T (assuming we can) we want a confidence interval the company can live with
- ex. if the company can live with an 80% confidence interval we choose T such that $D(T) \geq 80\%$ of the time

example: picking T

		confidence level						
		25%	40%	50%	60%	80%	90%	95%
	30	-39	-77	-100	-123	-177	-217	-250
	35	14	-26	-50	-74	-130	-172	-207
	40	67	25	0	-25	-84	-128	-164
T	45	121	77	50	23	-38	-85	-123
	50	174	128	100	72	7	-41	-82
	55	228	179	150	121	52	1	-41
	60	282	231	200	169	97	44	0

- F is normal with mean 400 and 90% worst case 500
- N is normal with mean 10 and 90% worst case 8
- cells are D(T) = N × T - F at the indicated confidence level
- important is transition through 0

example: picking T (2)

		confidence level						
		25%	40%	50%	60%	80%	90%	95%
	30	-39	-77	-100	-123	-177	-217	-250
	35	14	-26	-50	-74	-130	-172	-207
	40	67	25	0	-25	-84	-128	-164
T	45	121	77	50	23	-38	-85	-123
	50	174	128	100	72	7	-41	-82
	55	228	179	150	121	52	1	-41
	60	282	231	200	169	97	44	0

- 95% chance of hitting dates, choose T = 60, or…
- T = 40 ⇒ only a 5% chance of being > 20 days late
- to be 80% sure, select T = 49
- gamble with only a 25% chance, pick T = 33

shortcut

- ask for 80% worst case estimates for features
- if F = N × T using the 80% worst case values, then there is an 80% chance of finishing on time
- deterministic release plan can be based on this approach

- note: if you also ask for average cases you can fit a normal curve for D(T) and predict P(D(T)) < 0 (i.e. missing the date)