TIE-50407 Data Processing Implementations
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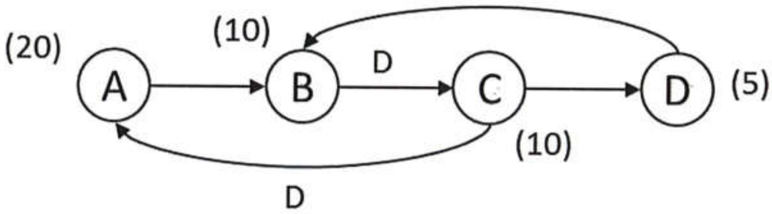
Exam March 6, 2019
Calculators and dictionaries are allowed

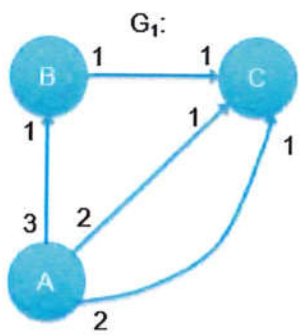
1. Explain shortly [1 point each]:
    a) Critical path
    b) Periodic schedule (in synchronous dataflow)
    c) IEEE-754 denormal numbers
    d) Truncation of magnitude rounding
    e) Dependency graph
    f) Loop bound

2. What is the decimal value of the binary number 1001101 when assuming
    a) 8-bit signed integer representation, [2 points]
    b) 8-bit fractional (signed) representation? [2 points]
    c) What is the largest representable number in representation of a), and b)? [2 points]

3. Consider the DFG shown below, where the number at each node denotes its execution time.
    a) What is the maximum sample rate of this DFG? [2 points]
    b) What is the fundamental limit on the sample period for the system described by this DFG? [2 points]
    c) Manually retime this DFG to minimize the clock period by using the node retiming technique. [2 points]



4. Consider the synchronous dataflow (SDF) graph G_1



    a) Define what *inconsistency* of an SDF graph means [2 points]
    b) Show that G_1 is inconsistent [2 points]
    c) Create a consistent graph G_1' by modifying *one* (input or output) actor sample rate in G_1 and show that G_1' is consistent [2 points]

5. Approximate ln(6) using 4 CORDIC iterations.

a) Which coordinates do you use (circular, linear or hyperbolic)? Do you use vectoring mode or linear mode? What is the function used to evaluate *d*? [2 points]

b) What initialization and post-processing is required? [2 points]

c) What is the approximation you get? [2 points]

n	*w* = arctanh 2^{-n}	*w* = arctan 2^{-n}
0	n/a	0.785400
1	0.549306	0.463648
2	0.255413	0.244979
3	0.125657	0.124355
4	0.062582	0.062419

$$\begin{cases} x_{n+1} = x_n - m d_n y_n 2^{-\sigma(n)} \\ y_{n+1} = y_n + d_n x_n 2^{-\sigma(n)} \\ z_{n+1} = z_n - d_n w_{\sigma(n)}, \end{cases}$$

$$d_n = \begin{cases} 1 & \text{if } y_n \leq 0 \\ -1 & \text{otherwise} \end{cases}$$

vectoring mode

$$d_n = \begin{cases} 1 & \text{if } z_n \geq 0 \\ -1 & \text{otherwise} \end{cases}$$

rotation mode

COMPUTATIONS USING CORDIC ALGORITHM IN DIFFERENT CONFIGURATIONS **NOTE:** ω in this table equals *z*

operation	configuration	initialization	output	post-processing and remarks
$\cos\theta, \sin\theta, \tan\theta$	CC-RM	$x_0 = 1$ $y_0 = 0$ and $\omega_0 = \theta$	$x_n = \cos\theta$ $y_n = \sin\theta$	$\tan\theta = (\sin\theta / \cos\theta)$
$\cosh\theta, \sinh\theta$ $\tanh\theta, \exp(\theta)$	HC-RM	$x_0 = 1$ $y_0 = 0$ and $\omega_0 = \theta$	$x_n = \cosh\theta$ $y_n = \sinh\theta$	$\tanh\theta = (\cosh\theta / \sinh\theta)$ $\exp(\theta) = (\cosh\theta + \sinh\theta)$
$\ln(a), \sqrt{a}$	HC-VM	$\sqrt{\ }$: $x_0 = a+0.25, y_0 = a-0.25$ ln: $x_0 = a+1, y_0 = a-1 \mid \omega_0 = 0$	$x_n = \sqrt{a}$ $\omega_n = \frac{1}{2}\ln(a)$	$\ln(a) = 2\omega_n$
$\arctan(a)$	CC-VM	$x_0 = 1$ $y_0 = a$ and $\omega_0 = 0$	$\omega_n = \arctan(a)$	no pre- or post-processing
division (b/a)	LC-VM	$x_0 = a$ $y_0 = b$ and $\omega_0 = 0$	$\omega_n = b/a$	no pre- or post-processing
polar-to-rectangular	CC-RM	$x_0 = R$ $y_0 = 0$ and $\omega_0 = \theta$	$x_n = R\cos\theta$ $y_n = R\sin\theta$	no pre- or post-processing
rectangular-to-polar $\tan^{-1}(b/a)$ and $\sqrt{a^2+b^2}$	CC-VM	$x_0 = a$ $y_0 = b$ and $\omega_0 = 0$	$x_n = \sqrt{a^2+b^2}$ $\omega_n = \arctan(b/a)$	no pre- or post-processing

The computation of $\tan\theta$ and $\tanh\theta$ require one division operation, while $\exp(\theta)$ and $\ln(a)$ require one addition and one shift, respectively, for post-processing. The computation of $\sqrt{a}$ and $\ln(a)$ require one increment and one decrement for pre-processing as shown in column 3, for "initialization".