CS 5130 Homework II

Liang Yan
From Computer Science

1. Answer the following questions related to reaching definitions analysis for the CFG
(a) Give the GEN and PRSV sets for each basic block

$U = \{r1@1, r10@2, r2@3, r11@4, r3@5, r15@6, r4@7, r13@8, r5@9, r14@10, r6@12, r14@13, r4@15, r14@16,$
$r1@17, r7@18, r15@19, r4@21, r11@22, r5@23, r15@24, r6@26, r10@27, r8@28, r11@29\}$

BB	GEN	PRSV
B0	r1@1,r10@2,r2@3,r11@4,r3@5	r15@6,r4@7,r13@8,r5@9,r14@10,r6@12,r14@13,r4@15,r14@16, r7@18,r15@19,r4@21,r5@23,r15@24,r6@26,r10@27,r8@28
B1	r15@6,r4@7,r13@8,r5@9,r14@10	r1@1,r10@2,r2@3,r11@4,r3@5,r6@12, r1@17,r7@18,r11@22,r6@26,r10@27,r8@28,r11@29
B2	r6@12,r14@13	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r4@15 r1@17,r7@18,r15@19,r4@21,r11@22,r5@23,r15@24,r10@27,r8@28,r11@29
B3	r4@15,r14@16,r1@17,r7@18,r15@19	r10@2,r2@3,r3@5,r13@8,r5@9,r14@10, r6@12,r14@13r5@23,r6@26,r10@27,r8@28
B4	r4@21,r11@22,r5@23,r15@24	r1@1,r10@2,r2@3,r3@5,r13@8,r14@10,r6@12,r14@13, r14@16, r1@17,r7@18,r6@26,r10@27,r8@28
B5	r6@26,r10@27,r8@28,r11@29	r1@1,r2@3,r3@5,r15@6,r4@7,r13@8,r5@9,r14@10,r14@13, r4@15,r14@16,r1@17,r7@18, r15@19,r4@21,r5@23,r15@24

(b)
Init.(iter.0)
IN(b) = $\emptyset$, OUT(b)=Gen(b) $\cup$ (IN(b) $\cap$ PRSV(b)) = Gen(b)

BB	IN	OUT
B0	$\emptyset$	r1@1,r10@2,r2@3,r11@4,r3@5
B1	$\emptyset$	r15@6,r4@7,r13@8,r5@9,r14@10
B2	$\emptyset$	r6@12,r14@13
B3	$\emptyset$	r4@15,r14@16,r1@17,r7@18,r15@19
B4	$\emptyset$	r4@21,r11@22,r5@23,r15@24
B5	$\emptyset$	r6@26,r10@27,r8@28,r11@29

iter.1
IN(b) = $\bigcup_{p \in pred(b)} OUT(p)$
OUT(b)=Gen(b) $\cup$ (IN(b) $\cap$ PRSV(b)) = Gen(b)

BB	IN	OUT
B0	$\emptyset$	r1@1,r10@2,r2@3,r11@4,r3@5
B1	r1@1,r10@2,r2@3,r11@4,r3@5,r4@21,r11@22,r5@23,r15@24	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9,r14@10,r11@22
B2	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r14@10,r4@15,r14@16,r1@17,r7@18,r15@19,r11@22	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r6@12,r14@13,r11@22
B3	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r6@12,r14@13,r11@22	r10@2,r2@3,r3@5,r13@8,r5@9,r6@12, r14@13,r4@15,r14@16,r1@17,r7@18,r15@19
B4	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8, r5@9,r14@10,r6@12,r14@13,r11@22	r1@1,r2@3,r3@5,r13@8,r14@10, r6@12,r14@13,r4@21,r11@22,r5@23,r15@24
B5	r1@1,r2@3,r3@5,r13@8,r14@10, r6@12,r14@13,r4@21,r11@22,r5@23,r15@24	r1@1,r2@3,r3@5,r13@8,r14@10,r14@13, r4@21,r11@22,r5@23,r15@24,r6@26,r10@27,r8@28,r11@29

iter.2
IN(b) = $\bigcup_{p \in pred(b)} OUT(p)$
OUT(b)=Gen(b) $\cup$ (IN(b) $\cap$ PRSV(b)) = Gen(b)

BB	IN	OUT
B0	$\emptyset$	r1@1,r10@2,r2@3,r11@4,r3@5
B1	r1@1,r10@2,r2@3,r11@4,r3@5,r13@8, r14@10,r6@12,r14@13,r4@21,r11@22,r5@23,r15@24	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r14@10,r6@12,r11@22
B2	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r14@10,r6@12,r14@13,r4@15,r14@16,r1@17,r7@18,r15@19,r11@22	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r6@12,r14@13,r4@15,r1@17,r7@18,r15@19,r11@22
B3	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r6@12,r14@13,r4@15,r1@17,r7@18,r15@19,r11@22	r10@2,r2@3,r3@5,r13@8,r5@9,r6@12, r14@13,r4@15,r14@16,r1@17,r7@18,r15@19
B4	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8, r5@9, r14@10,r6@12,r14@13,r4@15,r1@17,r7@18,r15@19,r11@22	r1@1,r10@2,r2@3,r3@5,r13@8,r14@10 r6@12,r14@13,r1@17,r4@21,r11@22,r5@23,r15@24
B5	r1@1,r10@2,r2@3,r3@5,r13@8,r14@10 r6@12,r14@13,r1@17,r4@21,r11@22,r5@23,r15@24	r1@1,r2@3,r3@5,r13@8,r4@10,r14@13,r1@17 r4@21,r5@23,r15@24,r6@26,r10@27,r8@28,r11@29

iter.3
IN(b) = $\bigcup_{p \in pred(b)} OUT(p)$
OUT(b)=Gen(b) $\cup$ (IN(b) $\cap$ PRSV(b)) = Gen(b)

BB	IN	OUT
B0	$\emptyset$	r1@1,r10@2,r2@3,r11@4,r3@5
B1	r1@1,r10@2,r2@3,r11@4,r3@5,r13@8,r14@10, r6@12,r14@13,r1@17 r4@21,r11@22,r5@23,r15@24	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r14@10,r6@12,r1@17,r11@22
B2	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r14@10,r6@12,r14@13,r4@15,r14@16,r1@17,r7@18,r15@19,r11@22	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r6@12,r14@13,r4@15,r1@17,r7@18,r15@19,r11@22
B3	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r6@12,r14@13,r4@15,r1@17,r7@18,r15@19,r11@22	r10@2,r2@3,r3@5,r13@8,r5@9,r6@12, r14@13,r4@15,r14@16,r1@17,r7@18,r15@19
B4	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8, r5@9,r6@12,r1@17,r11@22	r1@1,r10@2,r2@3,r3@5,r13@8, r6@12,r1@17,r4@21,r11@22,r5@23,r15@24
B5	r1@1,r10@2,r2@3,r3@5,r13@8, r6@12,r1@17,r4@21,r11@22,r5@23,r15@24	r1@1,r2@3,r3@5,r13@8,r1@17 r4@21,r5@23,r15@24,r6@26,r10@27,r8@28,r11@29

iter.4
IN(b) = $\bigcup_{p \in pred(b)} OUT(p)$
OUT(b)=Gen(b) $\cup$ (IN(b) $\cap$ PRSV(b)) = Gen(b)

BB	IN	OUT
B0	$\emptyset$	r1@1,r10@2,r2@3,r11@4,r3@5
B1	r1@1,r10@2,r2@3,r11@4,r3@5,r13@8, r6@12,r1@17 r4@21,r11@22,r5@23,r15@24	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r14@10,r6@12,r1@17,r11@22
B2	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r14@10,r6@12,r14@13,r4@15,r14@16,r1@17,r7@18,r15@19,r11@22	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r6@12,r14@13,r4@15,r1@17,r7@18,r15@19,r11@22
B3	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8,r5@9, r6@12,r14@13,r4@15,r1@17,r7@18,r15@19,r11@22	r10@2,r2@3,r3@5,r13@8,r5@9,r6@12, r14@13,r4@15,r14@16,r1@17,r7@18,r15@19
B4	r1@1,r10@2,r2@3,r11@4,r3@5,r15@6,r4@7,r13@8, r5@9,r6@12,r1@17,r11@22	r1@1,r10@2,r2@3,r3@5,r13@8, r6@12,r1@17,r4@21,r11@22,r5@23,r15@24
B5	r1@1,r10@2,r2@3,r3@5,r13@8, r6@12,r1@17,r4@21,r11@22,r5@23,r15@24	r1@1,r2@3,r3@5,r13@8,r1@17 r4@21,r5@23,r15@24,r6@26,r10@27,r8@28,r11@29

iter.5
No change
(c)
B0 $r1 \Rightarrow r1@1, r2 \Rightarrow r2@2$
B1 $r3 \Rightarrow r3@5, r10 \Rightarrow r10@2, r11 \Rightarrow r11@4 or r11@22, r4 \Rightarrow r4@7, r13 \Rightarrow r13@8, r10 \Rightarrow r10@2, r5 \Rightarrow r5@9, r14 \Rightarrow r14@10$
B2 $r11 \Rightarrow r11@4 or r11@22, r14 \Rightarrow r14@13, r6 \Rightarrow r6@12, r14 \Rightarrow r14@13$ B3 $r10 \Rightarrow r10@2, r11 \Rightarrow r11@22 or r11@4, r4 \Rightarrow r4@15, r15 \Rightarrow r15@19 or r15@6, r1 \Rightarrow r1@17, r7 \Rightarrow r7@18$ B4 $r10 \Rightarrow r10@2, r11 \Rightarrow r11@22 or r11@4, r4 \Rightarrow r4@21, r13 \Rightarrow r13@8, r10 \Rightarrow r10@2, r5 \Rightarrow r5@23, r15 \Rightarrow r15@24$ B5 $r11 \Rightarrow r11@22, r14 \Rightarrow r14@13, r6 \Rightarrow r6@26, r10 \Rightarrow r10@27, r14 \Rightarrow r14@13, r8 \Rightarrow r8@28$

2.Answer the following questions related to liveness analysis analysis for the CFG
(a) Give the GEN and PRSV sets for each basic block
$U = \{r1, r2, r3, r4, r5, r6, r7, r8, r10, r11, r13, r14, r15\}$

BB	GEN	PRSV
B5	r11,r14	r1,r2,r3,r4,r5,r7,r13,r14,r15
B4	r10,r11,r13	r1,r2,r3,r6,r7,r8,r10,r13,r14
B3	r10,r11,r15	r2,r3,r5,r6,r8,r10,r13,r14
B2	r11,r14	r1,r2,r3,r4,r5,r7,r8,r10,r11,r13,r15
B1	r3,r10,r11	r1,r2,r3,r6,r7,r8,r10,r11,r15
B0	$\emptyset$	r4,r5,r6,r7,r8,r13,r14,r15

(b)Liveness is a backwards problem, That is because to verify a node is liveness or not we , so we need to take postOrder to analysis it.

(c)
Init.(iter.0)
OUT(b) = $\emptyset$, IN(b)=Gen(b) $\cup$ (OUT(b) $\cap$ PRSV(b)) = Gen(b)

BB	OUT	IN
B5	$\emptyset$	r11,r14
B4	$\emptyset$	r10,r11,r13
B3	$\emptyset$	r10,r11,r15
B2	$\emptyset$	r11,r14
B1	$\emptyset$	r3,r19,r11
B0	$\emptyset$	$\emptyset$

iter.1
OUT(b) = $\bigcup_{s \in succs(b)} IN(s)$
IN(b)=Gen(b) $\cup$ (OUT(b) $\cap$ PRSV(b)) = Gen(b)

BB	OUT	IN
B5	$\emptyset$	r11,r14
B4	r3,r11,r14,r19	r3,r10,r11,r13,r14
B3	r11,r14	r10,r11,r14,r15
B2	r3,r10,r11,r13,r14,r15	r3,r10,r11,r13,r14,r15
B1	r3,r10,r11,r13,r14,r15	r3,r10,r11,r15
B0	r3,r10,r11,r15	r15

iter.2
OUT(b) = $\bigcup_{s \in succs(b)} IN(s)$
IN(b)=Gen(b) $\cup$ (OUT(b) $\cap$ PRSV(b)) = Gen(b)

BB	OUT	IN
B5	$\emptyset$	r11,r14
B4	r3,r10,r11,r14,r15	r3,r10,r11,r14
B3	r3,r10,r11,r13,r14,r15	r3,r10,r11,r13,r14,r15
B2	r3,r10,r11,r13,r14,r15	r3,r10,r11,r13,r14,r15
B1	r3,r10,r11,r13,r14,r15	r3,r10,r11,r15
B0	r3,r10,r11,r15	r15

iter.4
OUT(b) = $\bigcup_{s \in succs(b)} IN(s)$
IN(b)=Gen(b) $\cup$ (OUT(b) $\cap$ PRSV(b)) = Gen(b)

BB	OUT	IN
B5	$\emptyset$	r11,r14
B4	r3,r10,r11,r14,r15	r3,r10,r11,r14
B3	r3,r10,r11,r13,r14,r15	r3,r10,r11,r13,r14,r15
B2	r3,r10,r11,r13,r14,r15	r3,r10,r11,r13,r14,r15
B1	r3,r10,r11,r13,r14,r15	r3,r10,r11,r15
B0	r3,r10,r11,r15	r15